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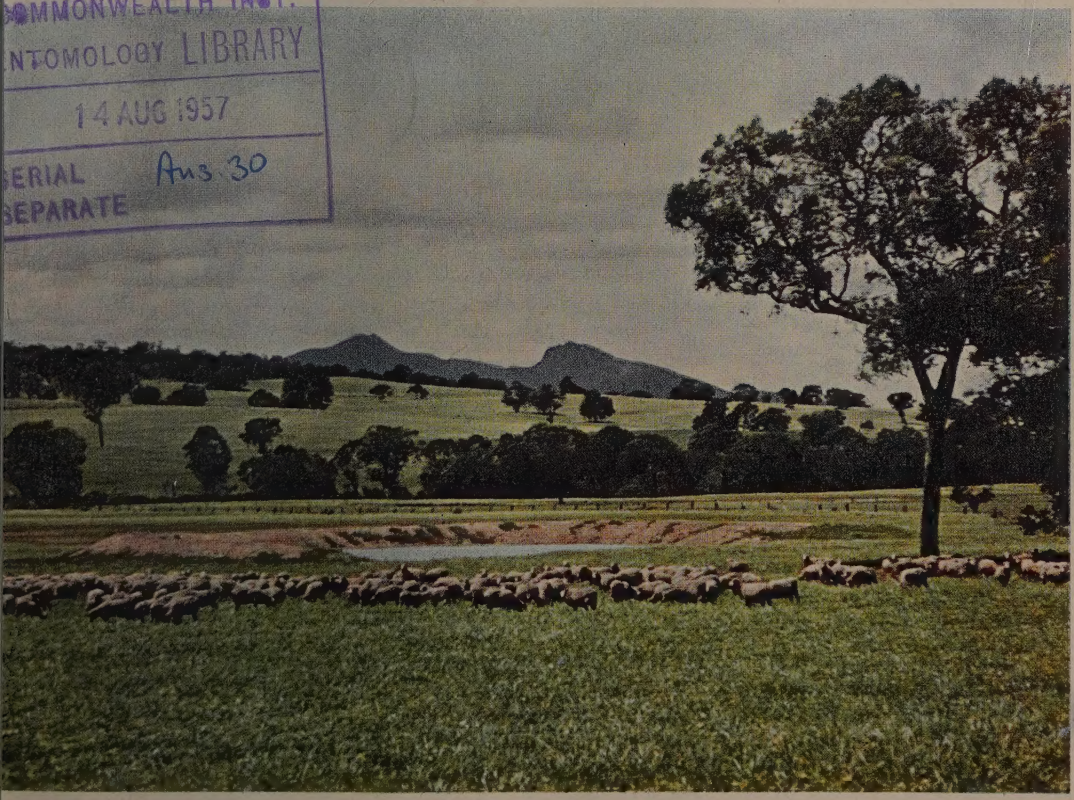

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COVER PICTURE

A pastoral scene at Mt. Barker with a glimpse of the Stirling Ranges in the background

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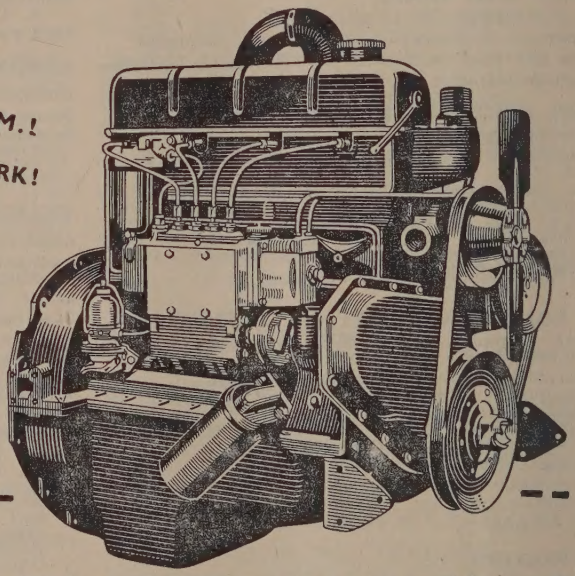

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THE PRUNING OF GRAPE VINES

Adapted from an article by the late H. K. JOHNS, formerly Viticulturist, Department of Agriculture

IN the intelligent pruning of the grape vine, many factors have to be taken into consideration—the age, size and condition of the plant; the location, soil and climate in which it is growing; the variety—in short, all the features of its environment and the principles governing its life.

The grape vine is perhaps the most responsive of all fruit-bearing plants to skilful pruning which is undertaken to achieve one or more of the following results:—

(a) To modify the shape or habit of the plant in order to facilitate cultivation, spraying and harvesting of the grape crop.

(b) To influence the size, quality and quantity of the fruit.

(c) To remove, renew and promote or retard the growth of portions of the plant.

TIME OF PRUNING

The time for pruning depends on the season's conditions. The only safe rule is that vines may be pruned as soon as they are dormant. If pruned too soon, the plants will be weakened and new growth will commence too early; then, if a frost is recorded, the young growth will be destroyed, with loss of fruitful shoots. Early pruning will cause the vines to start early growth in the spring, while late pruning will considerably delay the shooting of the buds. Generally, in this State, pruning commences in the month of June and is completed by the end of August.

THE PARTS OF THE VINE

As a knowledge of the parts of the vine is essential to a discussion on pruning methods, the beginner is advised to study Figs. 1 and 2, together with their captions.

PRUNING SYSTEMS

There are two distinct methods of pruning—spur pruning and rod pruning—and the two methods are applied individually or in combination according to the variety and habit of growth of the vine.

A rule worth remembering is that all vines bear fruit on the new wood but—with most varieties—bearing wood only grows from wood of the previous year's growth.

Vigorous growths sometimes appear on old wood such as the trunk or main arms of the vine. These are known as "water-shoots" and, as they do not usually produce fruit in their first season it is a safe rule for the amateur pruner to remove them. Water-shoots should only be left when it is desired to improve the shape of the vine by developing new arms.

Spurs.

A spur is a fruit-bearing cane that is cut back usually to two clear buds. The number of spurs to be left on a vine is a matter for the judgment of the pruner, as he must consider the variety and the vigour of the individual vine.

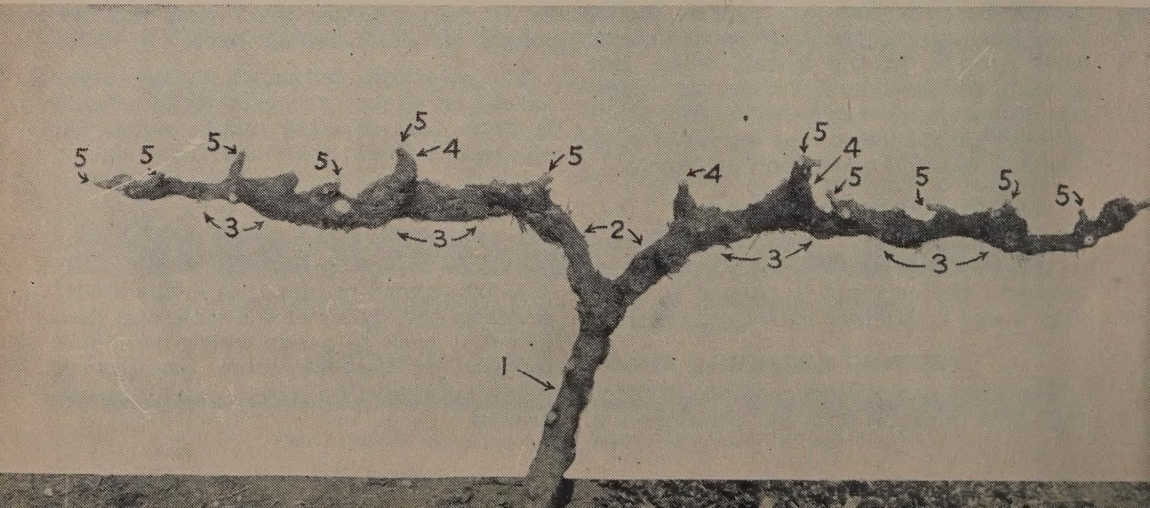
The strongest and most mature canes should be chosen as spurs which should be from four to eight inches apart. On no account should spurs be left in clusters.

If too many spurs are left on the vine the tendency will be for it to carry too many bunches of grapes. In this case the bunches and the berries may be too small. The art of good pruning lies in the ability to assess the vigour of the vine, and then to cut it back to a size which permits it to produce the maximum quantity of high-quality fruit without impairing its growth.

Fig. 1.—A 10-year-old Gordo Blanco Muscatel, grown in the Swan Valley, before pruning. 1.—Main trunk or body of the vine; 2.—Crown, formed at suitable commercial height for trellising; 3.—Main arms and permanent branches which are of mature wood several years old; 4.—Secondary arms arising from main arms and permanent branches; 5.—Canes of seasonal growth; 6.—Laterals growing from canes as seasonal secondary shoots; 7.—Water shoots which have grown from main trunk

Fig. 2.—The same vine after pruning, showing: 1.—Main trunk; 2.—Crown; 3.—Main arms; 4.—Secondary arms; 5.—Spurs

The system adopted in the pruning of the Gordo Blanco Muscatel is termed spur pruning along the main arms or cordons, the spurs being pruned to one clear bud. Swan Valley growers usually shorten back the spur to the basal bud with the object of lightening the crop and improving the quality. This variety of vine is a prolific bearer



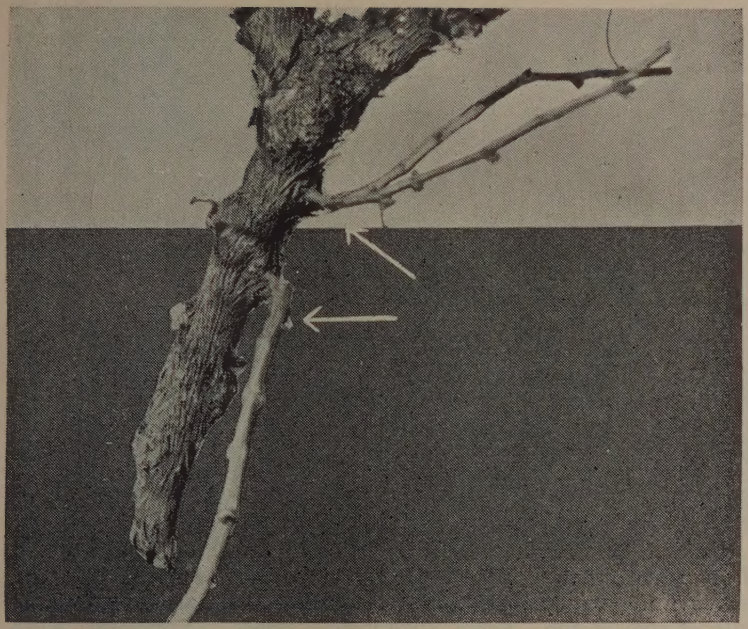


Fig. 3.—Water shoots growing from the main stem or body of the vine. These should be cut off by the pruner

Fig. 4.—Suckers which shoot from below ground level. The earth should be removed and the suckers cleanly removed. They are of no value and rob the parent stock

Fig. 5.—A vine trained on the Goblet or Gooseberry bush system, before pruning. This is the simplest and cheapest method of training grape vines and is popular in most commercial wine-growing vineyards, as this method facilitates cultivation

If more than two buds are left on a spur, the lower ones may not develop and the result is an increase in the size of the head and the length of the secondary arms. This places the leaves and grapes farther away from the main centre of the vine and increases the risk of damage during cultivation.

In pruning, the cut should be made midway along the internodes or space between two buds. If made too close to the bud, the top bud may be injured or dried out.

The following varieties may be spur pruned to produce and keep up the quality of the fruit—Gordo Blanco, Frontignac, Red Muscatel, Muscat Hamburg, Muscat Alexandria, Madresfield Court, Black Muscat, Canon Hall Muscat, Wortley Hall, Red and Black Malaga, Santa Paula, Gros Colman, Sweet Water, Grand Turk, Trebbiano, Valencia, Doradillo, Chasselas, Black Hamburg, Red Prince, Red May, Aramon, Grenache, Reisling, Matara, Malbec, Burgundy, Pedro, Ximenes, Blue Imperial, Zante Currants, Early Madeline.

Fig. 6.—The vine shown in Fig. 5 after pruning to the Basket-handle system which embodies spur and rod pruning in combination. The rods are interwoven. In the following season, they are removed and replaced by rods arising from the spurs

Fig. 7.—A vine spur-pruned to the Goblet system. Last season's spurs are cut off just outside the inner canes which in turn are cut back to spurs carrying two distinct buds. The pruning is designed to create a regular system of spur renewal. As the vine becomes older and more vigorous, more spurs are left to increase the yielding capacity. The head of the vine is kept well-balanced, and in due course, the arms may be renewed as required

Rods.

A rod is a fruit-bearing cane that is left much longer than a spur. It is usually cut to a length which allows it to retain from six to 14 buds.

In "rod and spur" pruning, the vine, after pruning, carries a certain number of long rods as well as the spurs pruned to two distinct buds. In the following prun-

Fig. 8.—A Shiraz vine before pruning

ing season the rods are removed and replaced by new rods from canes which have grown from the spurs. The spurs should be nearer the trunk than the selected rods, so that the vine does not increase in size too rapidly.

The following varieties respond well to rod and spur pruning—Shiraz, Malbec, Cabernet, Pinot, Sultana, Black Prince, Ohanez (Almeria), Waltham Cross, Lady's Finger, Flame Tokay, Knight's Centennial, Black St. Peter, Grand Turk, and Purple Cornichon.

PREPARATION OF CUTTINGS

Vine cuttings for propagation may be prepared at any time after vines have become dormant, when cuttings can be selected from the parent plant. They should range from 12 to 18 inches in length

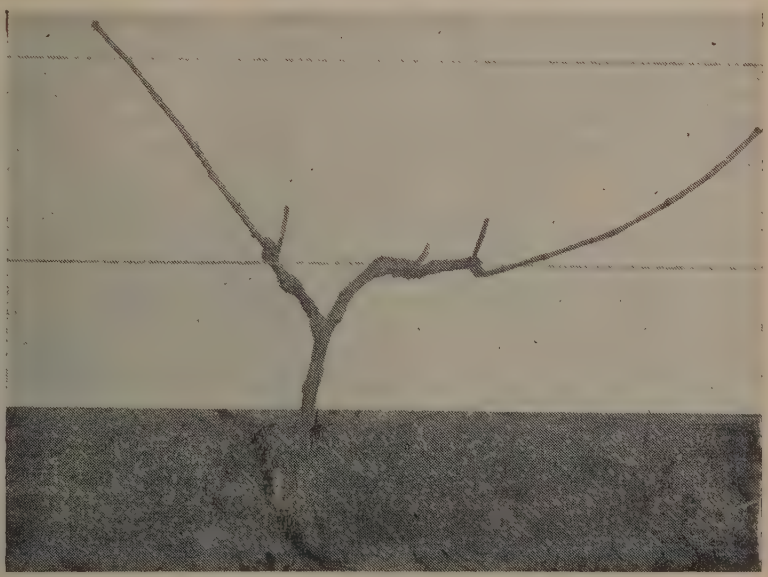


Fig. 9.—Shiraz vine after spur and rod pruning to the Bordelais Espalier or Double Guyot system. This is a system that is suitable for all varieties requiring rod and spur pruning. Annual pruning consists of removing the previous year's rods and water shoots, then utilising the canes from the previous year's spurs as rods and spurs. After pruning, the ends of the rods are tied to the bottom trellis wire. Note that the spurs are left inside the rods, or in other words, nearer the trunk of the vine. This keeps the vine compact and prevents undue extension of the main arms

Fig. 10.—Sultana vine before pruning. This variety yields heavily with long rod pruning

and should always be made from young matured wood and preferably from medium-sized short-jointed wood growths arising from spurs or canes (rods) of previous season's growth. To make cuttings, cut close below the lower bud, the cut to be square across, and leave about an inch of wood above the upper bud or eye.

Each cutting should preferably have the buds removed from the base end upwards, leaving the top two buds intact for production of growth. The reason for elimination of lower buds is to prevent the entry of fungous diseases or attacks by white ants which may result from the decomposing of the buds under ground. Soon after the commencement of the rise of sap and following growth, callousing will heal over all cuts, resulting in the trunk under ground being clean and well barked throughout. Cuttings should be tied in convenient-sized bundles, all buds pointing the same way. The bundles should then be buried in trenches with butt end up and covered with about six inches of soil. Inverting the bundles causes the butts to callous while the tops remain dormant, and the cuttings are ready to throw out a rooting system soon after planting in nursery or permanent position. If, on the other hand, they are heeled in with buds upwards, they often commence growth prior to developing root growth to support them.

When the ground has become warm enough, or in the early spring—August—plant the cuttings in well, deeply worked soil. If in a nursery, set each cutting at such a depth that only the upper two buds are just above surface level, spacing them

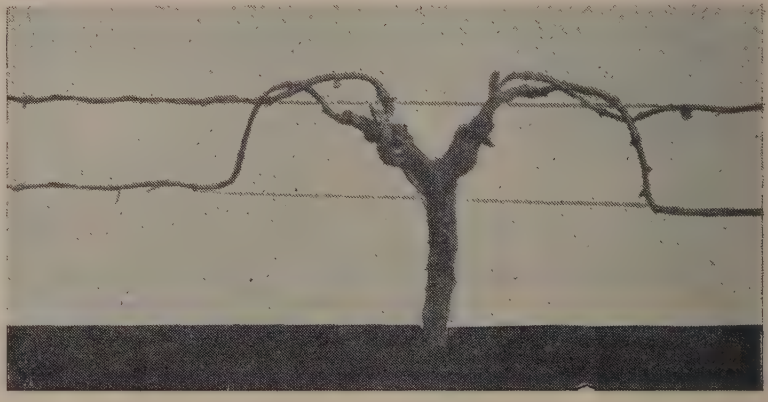


Fig. 11.—Sultana vine pruned to four long rods and also spurs pruned to two distinct buds. The rods are rolled round the trellis wires and tied at the ends. The number of rods to be left on the vine will depend upon its vigour and the local conditions

As the first four or five buds on the pruned rod will give very little fruit, it is advisable to control the vine during the growing period in order to produce rods carrying more fertile buds. This is done by tipping the terminals of shoots required for next season's pruning wood

about two to four inches apart with about three feet between rows. When selecting land for propagating cuttings, it is advisable, if possible, to have the sets in a position that can be irrigated with at least three or more waterings during the summer months. Also the soil should be well stirred with the hoe and cultivator to keep it mellow and as moist as possible. The principle involved is to create a good rooting and head growth the first year prior to planting in permanent position.

Fig. 12.—Cutting prepared for planting

TRAINING THE YOUNG VINE

The rooted cuttings growing in the nursery are lifted and planted in the vineyards while they are still dormant. They will usually appear similar in shape and growth to the sketch (Fig. 13). In deep sand, early planting is advisable.

Before planting the young vine is root-pruned as shown in the sketch and the top portion is pruned to two distinct buds.

Only one of these buds is allowed to grow; all other young shoots are removed during early growth, preferably when not more than six inches long.

This concentrates all the vigour of the young plant upon the cane which is destined to become the main trunk or body of the vine.

Care must be taken to stake and tie this upright growth until it reaches the required height for the formation of the crown. This protects it from wind damage and assists in forming a straight trunk.

Fig. 13.—A grape vine after one year's growth in the nursery. Before planting in the vineyard it should be root-pruned and the top portion cut back to two distinct buds as indicated by the dotted lines

If the trunk does not reach sufficient height in the first year, it should be cut back to a spur with two distinct buds at the next pruning season.

Again only one shoot should be allowed to grow from it and this shoot should be tied vertically. Where high structures are being covered with trellised vines it may take several seasons to grow a shoot of the required length.

Fig. 14.—A vine pruned after the first year in the vineyard. The most upright growth is selected and pruned to two distinct buds

When eventually the main shoot has grown to a height of nine or ten inches above the point where it is desired to form the crown, the terminal shoot is pinched off as shown by the X in Fig. 15. This promotes the growth of laterals which will subsequently form the main arms of the vine as indicated in the right-hand drawing, which shows the same vine after pruning.

The length of the trunk determines the height of the fruit-bearing canes from the ground and this varies according to requirements and is governed by several factors.

In the vineyard with the vines trained on the Goblet or Gooseberry bush system (see Figs. 5 to 7) a suitable height is 10 to 18 inches from ground level to crown formation.

Vines with short trunks and low crown formations are liable to damage from frosts and the grapes are likely to be damaged by cultivating machines and to collect dust. Taller vines are an advantage when pruning and picking the fruit.

With vines trained and grown on trellises in the field, the trunk length is usually about two feet, varying according to the variety.

ROOT TREATMENT

Many vines grow horizontal roots running outward from the trunk just under the surface of the ground; other roots penetrate deeply and run almost straight down.

Roots which are near the surface of the ground usually suffer severely during hot weather which is the time when the vine is called upon to perform its heaviest task —the propagation of foliage and wood and the growth and ripening of its fruit.

Fig. 15.—At left is a vine showing growth after pruning as in Fig. 14. Although it was pruned to two buds, only one was allowed to grow; all other young shoots have been removed when not more than six inches long. When the shoot has grown to nine or ten inches above the height required for crown formation, the terminal is pinched off at point marked X. This causes laterals to grow out where desired to form main arms. At right, the vine is shown after pruning

During their second and third year therefore, all young planted vines should be dug around to a depth of not less than six inches and all the roots in this depth of soil should be cut off close to the trunk.

This will tend to increase development of the deeper rooting system and will facilitate the deep cultivation which is necessary for the first ploughing during the winter months.

Care given to the young vines during their formative years will largely determine the profit and ease of working of the mature plants.

In this article, only the general principles of pruning have been given. No detailed instructions can be given which would apply to all vines in all soils, climates and localities, so that pruning methods must be modified to suit the individual requirements.

"The use of the grape as a food preceded the making of wine. Primitive man, who lived by the chase and on wild fruits, gathered and ate with relish the grapes of the wild vines long before he discovered that he could make a joyous beverage out of them. As time rolled on and life became more settled, he took in the grape vine from the wilderness and gave it cultivation. Then, perhaps, began the selection of the finest and best flavoured grapes, and presently the propagation of strains. Left to itself, deprived of man's ceaseless, thoughtful care, the grape vine would revert speedily, helplessly, to the status of its wild progenitor." (Extract from "Wine Lands of the World.")

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CURRANT AND MARMALADE TART

Make a short crust pastry and line a 7-inch sandwich tin. Bake at 400 deg. F. for 12 minutes or until half cooked. Combine the currants, marmalade, lemon and cakecrumbs. Add beaten egg. Pack into the pastry case. Return to the oven and cook until the pastry is cooked and lightly browned and the filling set. Cool and top with whipped cream or serve with boiled custard.

ENTEROTOXAEMIA ("PULPY KIDNEY") OF SHEEP

By C. R. TOOP, B.V.Sc.,
Chief Veterinary Surgeon

Fig. 1.—The outfit shown here is ideal for vaccinating against enterotoxaemia. It consists of a hypodermic syringe connected to a bottle containing the vaccine. The syringe is automatically re-charged after each injection

INFECTIOUS enterotoxaemia or the so-called "pulpy kidney" disease of sheep has been known to occur in Western Australia for many years and has been responsible for heavy though largely preventible losses. The earliest record of its occurrence dates back to 1915 when it appears to have been confined to the Great Southern districts and was known as "Beverley disease." With the cultivation and cropping of farm lands, it has since spread from that centre and, at the present time, the whole of the agricultural areas are involved.

The true nature of the disease was not determined until 1931 when it was shown by Bennetts to be caused by a microbe, commonly present in the soil, which multiplies in the small bowel of the sheep under certain conditions favourable to its growth and produces a potent toxin.

A vaccine prepared from cultures of this organism has proved effective for the prevention of the disease.

CONDITIONS UNDER WHICH THE DISEASE MAY OCCUR

Enterotoxaemia is mainly a disease of the flush season. The majority of outbreaks occur between April and October when green feed is abundant, and losses are heaviest during favourable seasons. Deaths may commence at any time during this period and may continue until the mortality is checked by the drying off of

the feed in late spring. Losses are usually intermittent, a few sheep being found dead at a time at irregular intervals, but in the aggregate the mortality may reach serious proportions and has been known, during the course of a season, to account for 30 per cent. of a flock.

This is the usual pattern but occasionally sudden and severe mortalities may be experienced when a large number of sheep may be lost within a short space of time.

LOSSES UNDER DRY FEED CONDITIONS

Losses from enterotoxaemia are not confined to the flush season; they may also occur during the dry period of the year. Mortalities associated with the consumption of flowering stinkwort during the late summer months when feed is scarce are not uncommon and outbreaks have often been reported amongst flocks running on peas or on wheat crops left unharvested because of storm damage or poorness of yield, and where a supplementary ration of concentrates has been fed.

THE CAUSE OF THE DISEASE

Enterotoxaemia is caused by the microbe *Clostridium welchii* Type D, which is frequently present in the soil of farmlands where it is able to persist for long periods by the formation of spores. Because of its wide distribution this organism must frequently be ingested by sheep while grazing, but it normally passes through the digestive tract without producing any ill effects. When, however, conditions are favourable to its growth, it multiplies in the small intestine producing a powerful toxin the absorption of which results in the death of the sheep usually within the space of a few hours. It has been shown that a condition which favours this abnormal upgrowth of the organism is a temporary stasis or sluggishness of the bowel but just how it is brought about does not yet appear to be clearly understood.

THE PREDISPOSING FACTORS

Fibre and Exercise.

Green feed is the principal predisposing factor. When young and luxuriant it is low in fibre and high in moisture content and, in addition, the sheep is able to obtain its food requirements with a minimum of effort.

It is well known that both fibre and exercise stimulate bowel activity and when these factors are lacking or not fully operative, it would be reasonable to expect that a slowing down of the movements of the bowel predisposing to enterotoxaemia would occur. Similar effects could also be expected from the consumption of dry peas, fallen grain or a ration of concentrates, all of which are low in fibre content.

Injury to the Bowel Wall.

When stinkwort is consumed by sheep in the flowering and seeding stage the small barbed hairs of the pappus (developing fruit) penetrate and adhere to the bowel wall and are often so numerous in the small intestine as to form a feltwork covering a large area of the lining membrane. The damage inflicted by these hairs predisposes to enterotoxaemia and the outbreaks which occur in sheep having access to the plant in late summer are a sequel to their penetration.

SYMPTOMS

Sheep of all breeds and of all ages are susceptible. Losses are usually distributed fairly evenly throughout the flock, but in some outbreaks the mortality may be largely confined to grown sheep while in others it occurs mainly in lambs.

In Western Australia lambs seldom become affected before the age of 10 to 12 weeks whereas in New Zealand and parts of Eastern Australia mortalities are heaviest in lambs during the first few weeks of life.

It has often been remarked that sheep in fat condition most frequently become affected and, while this may be so during the flush season, it is by no means always the case. Sheep dying of enterotoxaemia in late summer are often in store condition.

An outstanding feature of the disease is the suddeness of death and the symptoms are of such short duration that affected sheep are seldom noticed ailing. More often their carcasses are found in the paddocks highly distended with gas, discoloured and undergoing rapid decomposition.

Fig. 2.—If the injection is made on the side of the brisket behind the elbow any resulting carcass blemish can be readily trimmed off

When symptoms are observed the affected sheep will be noticed to lag behind the flock moving about with its nose to the ground and often chewing excitedly at sticks, stones and other small objects. Champing of the jaws is usual and there is sometimes a frothy discharge of saliva from the mouth. Scouring with the passage of liquid excretions which soil the breech may also occur, but this is by no means a constant symptom.

The gait is weak and unsteady and the animal may knuckle over at the fetlocks or go down on its knees. Soon it is unable to stand and lies on its side with the head turned in towards the flank. From this stage it rapidly sinks into a condition of coma and dies often without shifting its position in three to four hours of the first appearance of symptoms.

Occasionally in lambs, less often in grown sheep, there are convulsive symptoms. The animal, apparently in normal health, is suddenly seized by convulsions. It falls to the ground lying outstretched on its side with the head turned backwards making violent struggling movements until death supervenes—usually within two to three hours.

An atypical form of the disease has been described in which death is delayed for 18 to 24 hours and is preceded by aimless wandering, but this must be regarded as unusual.

POST-MORTEM APPEARANCES

A post-mortem examination carried out immediately after death will reveal few abnormalities. Slight changes, however, are usually present, the most constant of which are subendocardial haemorrhages which appear as rather large bluish blotches beneath the lining membrane of the inner surface of the heart. Similar, though much smaller haemorrhages may also be observed on the epicardium or outer surface of the heart and there is often an excess of fluid in the heart sac. The small intestine may be somewhat distended with gas and its contents reduced in quantity and the blood vessels which supply it may be congested and appear more prominent than usual.

Post-Mortem Decomposition of the Carcass—Pulpy Kidney.

Putrefaction commences immediately after death and thereafter proceeds at an extremely rapid rate. After lying a few

hours the carcass will usually have become greatly bloated with gas and the wool may be plucked from it without difficulty, while the inside surfaces of the thighs and forearms, which are bare of wool, may show a green or purplish discolouration. Upon opening the abdominal cavity the intestines will be found to be highly distended with gas and the extent of the putrefactive changes, which have already occurred in the internal organs, will be apparent. The kidneys in particular undergo very rapid decomposition and will be observed to have broken down to a soft pulpy mass of dark red tissue and to have lost their well-defined shape—hence the name "pulpy kidney" by which the disease is popularly described. It must be amphasised, however, that "pulpy kidney" is a post mortem change and that it is not observed in the fresh carcass.

DIAGNOSIS

When deaths are occurring suddenly and irregularly, particularly during the flush season, and this is followed by abnormally rapid bloating and decomposition of the carcass and a post mortem examination carried out a few hours after death has revealed the kidneys to have become characteristically pulpy and degenerated, a diagnosis of enterotoxaemia will, in most cases, be justified. But where it is desired to confirm the diagnosis a sample of the small bowel contents should be submitted for laboratory examination. Filtrates from the small bowel contents of a sheep affected by enterotoxaemia, because of their toxin content, are rapidly fatal when injected into laboratory animals, whereas similar material from healthy sheep or from sheep dying of other causes produces no ill effects.

Small bowel contents are of no value for diagnostic purposes unless obtained from a freshly dead sheep and should therefore be collected and despatched as soon after death as possible. The intestine should be tied off at its junction with the the fourth stomach and again where it joins the caecum or blind gut and then freed of its attachments. By drawing it between the thumb and forefinger, the contents are forced to one end and may then be transferred to a wide mouthed specimen bottle. A few drops of chloroform (0.5 cc. per 100 cc. of contents) should be added as a preservative and the specimen despatched to the laboratory without delay. Specimen bottles, together with preservative, may be obtained on application at the Animal Health and Nutrition Laboratories, Hollywood, Western Australia.

PREVENTION—INOCULATION WITH ENTEROTOXAEMIA VACCINE

Before the advent of vaccines, various expedients were employed to prevent mortality. It was a common practice to move the sheep from paddock to paddock at frequent intervals; to yard them periodically, or to transfer them to a bare paddock and these measures, by reducing the intake of food and providing the flock with exercise, often checked the losses. It was also possible, by moving the sheep to a scrub paddock, which provided a diet high in fibre content, to arrest the mortality completely.

Inoculation with enterotoxaemia vaccine, however, provides the only means of prevention which is both practical and effective. A sheep injected with this product will, after an interval of 10 to 14 days, develop an immunity which will enable it to resist the disease if subsequently exposed.

The use of an alum-precipitated, trypsinised vaccine of high potency is recommended and it should be given at the maximum dosage advised by the manufacturer. The immunity derived from a single injection is not of a high order and, in order to obtain a safe and satisfactory degree of protection, a second injection after an interval of not less than 30 days is necessary. The first of these injections is to be regarded as a sensitising dose; the second boosts the immunity to a much higher level which reaches its peak in a fortnight and remains effective for about six months.

It has been the custom in Western Australia to rely on a single injection and the results have generally been found satisfactory. Breakdowns have, however, occurred, and in favourable seasons in which serious mortalities may be anticipated a second inoculation after an interval of 30 days is

strongly recommended and this, under any circumstances, is the safest procedure to adopt.

When to Inoculate.

Since the greatest losses from enterotoxaemia occur during the winter and spring months, it is recommended that the inoculation of the flock be completed in April or May before the advent of the opening rains so that the sheep may enjoy the highest measure of protection during the period of greatest risk.

Where sheep are to be fattened on peas or turned on to storm-damaged wheat crops they should be immunised immediately beforehand and a similar precaution should be taken against the risk of mortality in the case of sheep running on flowering stinkwort in late summer.

Immunisation of Lambs.

Lambs should be inoculated at the time of marking and to ensure that a satisfactory level of immunity is established and maintained, a second injection should be given a month later. The vaccine should be used in the same dosage recommended for grown sheep and the injection should be made just beneath the skin on the side of the brisket behind the elbow where any blemish that may result may be readily trimmed from the dressed carcass. Care should be taken to avoid penetration of the under-lying muscles with the tip of the needle.

Young Lambs.

In those parts of Australia where heavy losses occur in lambs during the first few weeks of life, immunisation presents a special problem. Because of the very early age at which deaths occur and the interval which elapses prior to the development of a serviceable immunity, the use of enterotoxaemia vaccine is precluded and resort must be had to the immunisation of the young lamb through its mother. The ewe is inoculated with enterotoxaemia vaccine at the time of mating and a second injection is given 10 to 14 days before lambing. By this time the immunity conferred upon the ewe will have reached its peak and it is transmitted to the lamb through the colostrum or first milk sucked. It is a passive immunity of short duration but it persists long enough to protect the lambs during the first four to six weeks of life.

Since lambs seldom become affected in this State before the age of about three months this practice appears to be unnecessary in Western Australia but, should unexpected mortalities occur in young lambs, losses may be stopped immediately with pulpy kidney antitoxin.

MEASURES NECESSARY TO CONTROL AN OUTBREAK

When an outbreak of enterotoxaemia occurs in a flock which has not been immunised, further deaths may be prevented by the injection of pulpy kidney antitoxin in a dosage of 5 cc. for young lambs and 10 cc. for older lambs and grown sheep. This product confers an immediate protection but it is of very short duration and lasts only for about two weeks but it may nevertheless tide the flock over a difficult period. The treatment of grown sheep with antitoxin is costly and amounts to about 4s. per head. If it is desired to prolong the immunity the sheep should be injected at the same time, but on the opposite side of the body with enterotoxaemia vaccine and a second injection of the vaccine should be given a month later. By this means an immunity which is both immediate and lasting will be obtained.

Alternatively—and this will be found much cheaper and perhaps a more practicable procedure—the flock may be inoculated with enterotoxaemia vaccine and then transferred to a bare paddock or to scrub country for 14 days to enable an immunity to become established and the injection should be repeated after 30 days.

Where a breakdown of immunity has occurred in a previously inoculated flock, the sheep should be re-vaccinated without delay. This will boost the immunity to an effective level and may be relied upon to prevent further deaths.

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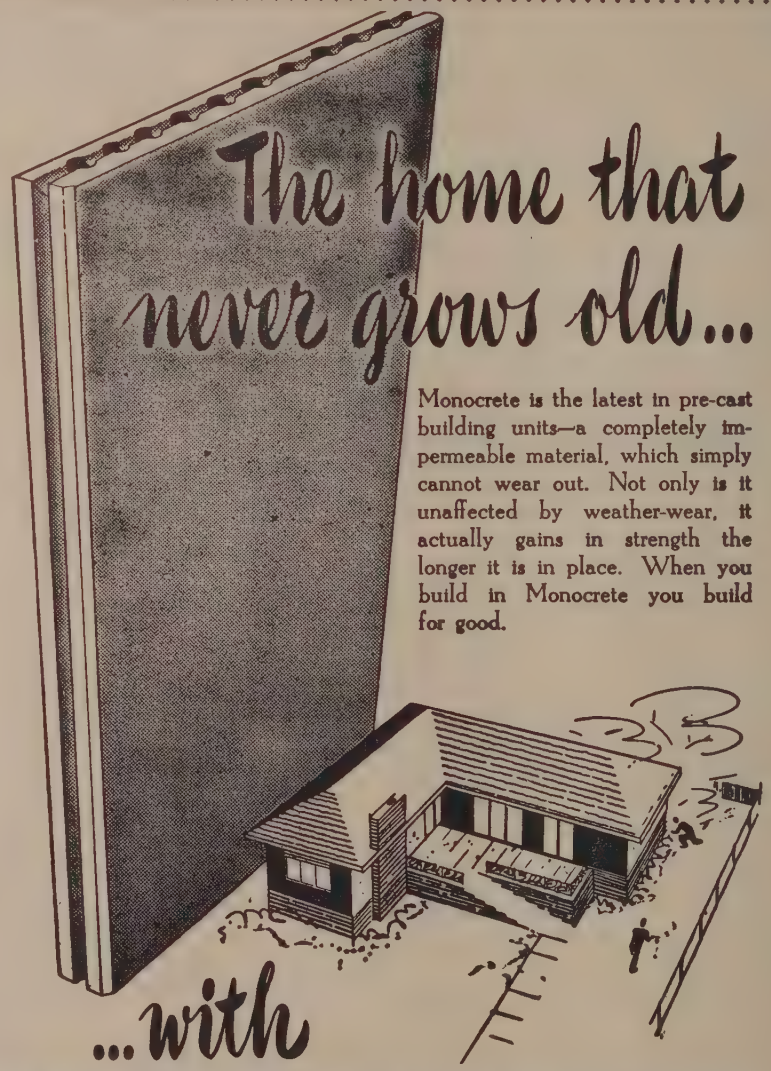

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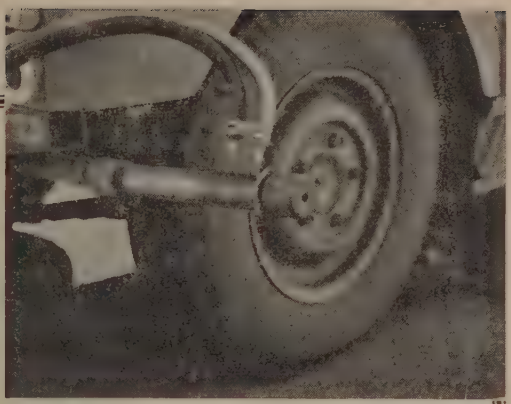

Fig. 1.—The sprayer in position on a Land Rover exhaust-pipe

By C. F. H. JENKINS, Government Entomologist, and A. R. TOMLINSON, Chief Vermin Control Officer

SPRAYING with dieldrin mixtures before the insects reach the flying stage has given excellent results in controlling grasshopper plagues, and the Agriculture Protection Board is supplying dieldrin spraying material free of charge to farmers in the Eastern, North-Eastern and Northern Agricultural Areas.

The application of the spraying material by farmers who did not possess boom spraying equipment presented many problems in the past, but it is felt that this inexpensive, simply-constructed spraying unit operated by the exhaust gases of a motor vehicle may provide a satisfactory method of destroying the pests in the "hopper" stage.

The exhaust spraying unit is an adaptation of a device first used for desert locust control in South Africa and was developed by the South Australian Department of Agriculture for use in grasshopper control in that State.

Following upon the publication of constructional details by F. W. Osborne in the South Australian Journal of Agriculture (Vol. 59 No. 7, February, 1956, pp. 268-270) trial models were made in this State by Malloch Bros. Ltd. who indicated that they would be able to market the units at approximately £7 15s. each.

The home construction of the unit should present no great difficulties to the farmer with access to a well-equipped workshop.

TEST PERFORMANCES

In tests conducted at Southern Cross by Supervising Vermin Control Officer A. G. Veitch in September 1956, the sprayer operated very well and wiped out a fairly heavy grasshopper concentration.

The sprayer was fitted to a long wheelbase Land Rover which, when travelling at 10 miles per hour in second gear, gave a spray coverage of a strip 9ft. wide. Using a mixture of one gallon of 25 per cent. dieldrin emulsion in 40 gallons of water, 22 acres were sprayed in two hours applying slightly under 2 gallons per acre. The recommended application is 1¼ to 2 gallons per acre.

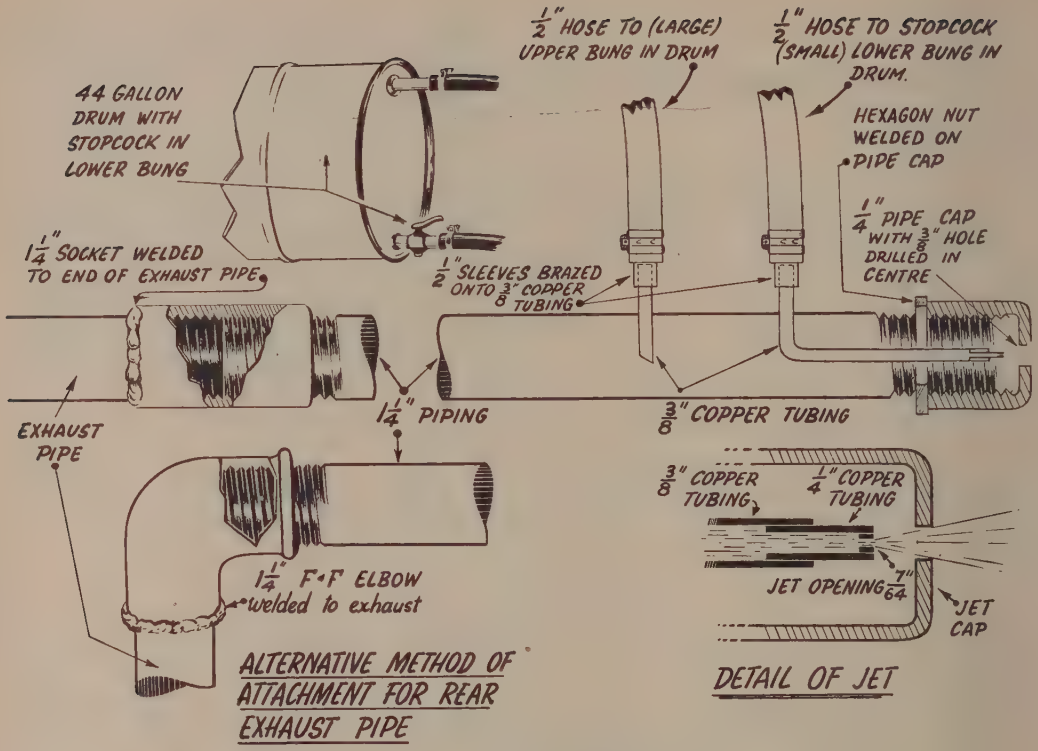
½" HOSE TO (LARGE) UPPER BUNG IN DRUM
½" HOSE TO STOPCOCK (SMALL) LOWER BUNG IN DRUM.
44 GALLON DRUM WITH STOPCOCK IN LOWER BUNG
HEXAGON NUT WELDED ON PIPE CAP
¼" PIPE CAP WITH ⅜" HOLE DRILLED IN CENTRE
1¼" SOCKET WELDED TO END OF EXHAUST PIPE
½" SLEEVES BRAZED ONTO ⅜" COPPER TUBING
EXHAUST PIPE
1¼" PIPING
⅜" COPPER TUBING
⅜" COPPER TUBING
¼" COPPER TUBING
1¼" F·F ELBOW welded to exhaust
JET OPENING 7/64"
JET CAP
ALTERNATIVE METHOD OF ATTACHMENT FOR REAR EXHAUST PIPE
DETAIL OF JET

Fig. 2.—Diagrams showing the constructional details of the exhaust spray unit

CONSTRUCTIONAL DETAILS

The sprayer utilises the exhaust gas pressure of a motor vehicle to atomise spray liquid and distribute it over the ground. It may be operated by any motor vehicle with four or more cylinders.

The spray solution is carried in a 44 gallon drum mounted horizontally on the vehicle. It is fed through a length of ½in. hose to a small jet and broken into a spray by the pressure of exhaust gases being ejected through an opening round the jet orifice.

The insecticidal solution is sprayed out at right angles to the vehicle's line of travel and the unit may be clamped to the rear bumper bar or any suitable portion of the vehicle.

Preparing the Drum.

The drum is placed on its side in the vehicle with the top facing to the rear, and the large bung or plug, uppermost. This large bung is bored and fitted with a short length of ½in. tubing to take a length of ½in. rubber or plastic hose. If the large bung is a white metal die-casting, it is preferable to replace it with one made of steel or brass.

The small bung is replaced by ½in. stopcock to take a similar length of hose. This tap must be shut off when the sprayer is not in use, as otherwise the spray liquid will leak away through the jet nozzle.

The Spray Unit.

The body of the spray unit is a length of 1¼in. galvanised piping threaded at each end. The actual length of the piping will depend upon the type of vehicle used, the position of the exhaust pipe and similar factors.

The 1¼in. piping is drilled in two places to take two lengths of ⅜in. diameter copper tubing. The one farthest from the jet extends into the centre of the 1¼in. piping and has a length of ½in. tubing brazed to the outside end to take the length of hose extending to the upper or large bung on

the drum. This allows sufficient gas pressure from the exhaust to build up in the drum to maintain a steady flow of solution from the lower bung.

The other length of copper tubing is bent at right angles inside the 1¼in piping and extends to the outer end. A short length of ¼in. copper tubing brazed into the outer end of the ⅜in. copper tubing constitutes the jet. It should project ½in. beyond the end of the 1¼in. piping and should have the orifice reduced to exactly 7/64in. in diameter. The other end of the tube also carries a ½in. tubing sleeve connected to a length of ½in. hose running to the stopcock.

A 1¼in. pipe cap—or a 1¼in. socket with one end closed by a welded-in disc—is used as a jet cap. This cap has a ⅜in. hole in the centre to provide an outlet for the exhaust gases, and spray droplet size is adjusted by screwing this jet cap in or out. For ease of adjustment a 1¼in hexagon nut is welded to the cap. The best results are obtained by adjusting the jet cap to give the maximum outlet for exhaust gases. If screwed down too far, it restricts the escape of the gases to such an extent that too much pressure may build up in the drum.

When the spray unit is not in use, this jet cap is removed and replaced by an ordinary open-ended 1¼in. socket. This allows the exhaust gases to escape freely and protects the jet.

Connecting to the Exhaust Pipe.

In the Land Rover and vehicles which have the exhaust pipe projecting at right angles to the line of travel, a 1¼in. socket welded on to the end of the exhaust pipe is all that is needed for the attachment of the spray unit, although suitable clamps may be needed to support the unit and prevent undue vibration.

Where the exhaust pipe points to the rear, a 1¼in. F.F. elbow can be fitted with or without suitable reducing sockets, according to the size of the pipe.

OPERATING HINTS

As the filled drum weighs about 4 cwt. some bracing of the floor of the vehicle may be necessary.

The slower the road speed of the vehicle, the more liquid will be applied per acre.

The engine revolutions must be kept high enough to ensure that the spray output is adequate. When going down hill it may be necessary to change to a lower gear. A little practice will soon overcome these difficulties.

The spray jet orifice must be kept at exactly 7/64in.—no smaller and no larger. Any alteration will influence the effectiveness of the spray.

It is important to ensure that the exhaust system of the vehicle is free of leakages from manifold to the tail of the exhaust pipe. Even a small leakage will greatly reduce the efficiency of the spray unit.

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SORREL

(*Rumex acetosella* L.)

In Europe, Sorrel is regarded as an indicator of acid soils and the application of lime is frequently advocated as a control measure. In Western Australia it also grows on sour, poorly drained land but such conditions are by no means essential. Many seeds are produced, and new plants develop rapidly from small portions of the underground stems.

WEEDS of Western Australia

By **G.R.W. MEADLY** M. Sc.
Officer in Charge, Weeds and Seeds Branch

SORREL

(Rumex acetosella L.)

ALTHOUGH Sorrel or Sheep Sorrel as it is often called is native to Europe and Southern Asia, it is now recorded from many countries in the world and reference is made to it in most books dealing with weeds.

In England, it is regarded as being an indication of poor, sandy soils deficient in lime. In Australia, however, although it is found frequently on soils that are badly drained and wet in winter it is by no means confined to them. Our experience indicates that it is capable of thriving on a variety of soil types, but is most conspicuous on sour soils where it is subjected to little competition from other plants.

The early history of Sorrel in Australia is obscure but it now occurs in all States and there is little doubt that it first appeared during the early days of settlement. The seeds are often found as an impurity in agricultural seeds, particularly of European origin and no doubt early introductions were made in this manner.

Sorrel is found most frequently in the moister parts of the South-West, particularly on low lying portions of the coastal plain. It also occurs, however, in the drier areas on well drained soils and the red colouration associated with the prolific flowering and seeding is not uncommon in the wheatbelt.

DESCRIPTION

Sorrel is a perennial herb with a creeping rhizome and slender erect stems 4-18 inches in height, often turning red. The leaves are alternate, the lower ones usually dagger-shaped and the upper ones narrower, being lance-shaped or even linear. All are hairless and stalked. The stipules —small structures at the base of the leaves —are thin and papery, usually white or silver in colour and forming a ring around the stem. Male and female flowers are formed and both are inconspicuous, neither having the coloured petals usually associated with floral structures. The female flowers give rise to small, triangular nutlets, each of which contains a single seed of similar shape.

The plant flowers and seeds in the spring and summer.

Sorrel means, "of a reddish brown colour" and the name obviously refers to the colouration of the stems, flowers and nutlets, a feature most noticeable when the plants are maturing under dry conditions.

SIGNIFICANCE

Sorrel, like the related docks, has a high oxalic acid content which makes it relatively unpalatable. It is eaten to a certain extent by stock, however, possibly while grazing other herbage rather than by choice. It has affected animals, particularly breeding ewes, but is seldom regarded as having toxic properties.

Although a weed of both pastures and crop land, Sorrel is probably most troublesome in orchards and gardens, particu-

SORREL (Rumex acetosella L.).

A—Plant showing habit; B—Leaf; C—Male flower; D—Anther; E—Female flower; F—Fruit; G—Seed; H—Transverse section of seed.

(From a drawing by C. A. Gardner, Government Botanist.)

larly market gardens. Its vigorous perennial habit provides strong competition for crop plants but it is affected by shading and the growing of appropriate crop and pasture species is a worthwhile control measure.

CONTROL

Control is made difficult by several features of this tenacious weed. It seeds very freely and the seeds are contained in a protective nutlet, enabling them to retain their vitality in the soil for a long time. Sorrel often appears on clean land following cultivation, the seeds having remained dormant for years until provided with favourable conditions for germination.

The plant itself is a vigorous perennial with an extensively developed underground stem and root system, giving rise to surface shoots at intervals. Fragments of these stems or runners are capable of producing new plants, and spasmodic ploughing or cultivation serves to spread rather than control the weed. Stock distribute the plant by passing undigested seeds and it is also spread as an impurity in grass and small clover seeds, especially white and drooping-flowered clover. Seeds do not occur in graded subterranean clover seed but are found in burr and rough samples.

Preventing the weed from becoming established is, of course, preferable to attempting eradication later. Any plants noticed should be forked out and burned, remembering the importance of destroy- the seeds and underground parts. On larger areas the land should be ploughed in the early spring before flowering has occurred, following up with spring-tyne cultivation as often as necessary during the summer. The objective of the repeated cultivation is to lift the underground stems and expose them to the drying effects of the sun. With the first rains of the following season, oats or some other smothering crop should be sown.

Besides being a large undertaking where extensive areas are involved, from a soil conservation viewpoint summer workings are seldom desirable and this method, therefore, has limitations. Sorrel in market gardens, especially on the coastal sandy soils, can be reduced to very small proportions by regular rotary hoeing during the spring and summer. If the affected section is treated as a unit there is less risk of carrying the plant to clean portions of the paddock. Summer waterings naturally encourage the weed.

Drainage and the use of lime are beneficial when warranted by the conditions but, as already pointed out, many affected areas are well drained and not deficient in lime. When practicable, the most economical method of dealing with heavy infestations is to establish and maintain a vigorous pasture. Where possible perennial species such as white clover, strawberry clover and paspalum should be grown but subterranean clover and drooping flowered clover are also suitable. Such pastures will not necessarily eliminate the weed but, by competing strongly, will reduce its significance.

Sorrel is not readily affected by chemicals which have a limited use in its control. A 10 per cent. solution (1 lb. per gallon of water) of sodium chlorate applied at the rate of one gallon to 20-30 square yards will dry the plant back to ground level but further growth must be treated as it appears. A similar check can be obtained with a solution containing 2 lb. acid equivalent of 2,4-D ester in 100 gallons of water. Both these treatments affect other plants.

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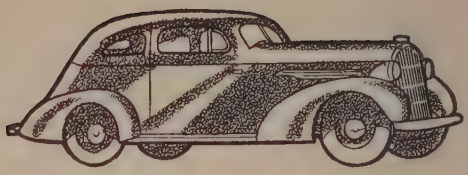

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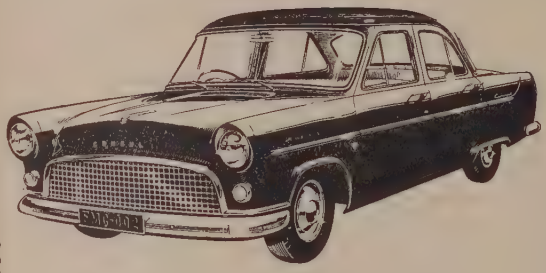

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NEW AND USED CARS AND UTILITIES

INSECT Pests AND THEIR CONTROL

By B. A. B. EDWARDS, B.Sc. (Agric.), Entomologist

TOBACCO PESTS

Experiments In Their Control In Western Australia

EXPERIMENTS have been conducted at Manjimup, Western Australia, for the control of insects attacking tobacco. The insects concerned include the leaf miner, stem borer, cutworms, looper caterpillars and grass hoppers.* The insecticides used were lead arsenate, DDT, dieldrin, aldrin and endrin. As applied, i.e., at equal intervals during the growing season and at the strengths used, DDT proved superior to all other treatments.

Of the insects which attack tobacco after planting out, the present article deals with two particular types, the leaf miner and leaf chewing insects. The latter includes cutworms, looper caterpillars and, to a lesser degree, grasshoppers.

Until the advent of DDT, control measures were carried out with arsenical dusts and baits (Newman 1931) but in recent years DDT has been found more effective either as a spray or as a dust (Cannon, 1946). Interest also arose in the chlorinated hydrocarbons, aldrin, dieldrin, and endrin, for tobacco pest control.

EXPERIMENT, 1952-53

This experiment was designed to compare the effectiveness of lead arsenate dust, DDT dust and DDT spray both on the leaf miner and on those chewing insects causing leaf damage.

I. Treatments.

The following treatments were decided on after a survey of the literature:—

(i) Control—no treatment.

(ii) 50 per cent. lead arsenate dust—5 applications.

(iii) 50 per cent. lead arsenate dust—3 applications.

(iv) 2 per cent. DDT dust—5 applications.

(v) 2 per cent. DDT dust—3 applications.

(vi) 0.1 per cent. DDT spray—5 applications.

(vii) 0.1 per cent. DDT spray—3 applications.

II. Site.

The site selected was on the Department of Agriculture's Tobacco Research Station located six miles west of Manjimup, Western Australia.

* The scientific names of pests are listed at the end of the paper.

III. Design.

A randomised block design with five replications of the seven treatments was used. Each plot consisted of five rows of tobacco plants each one chain long and containing approximately 33 plants in every row.

The variety used in all experiments in the present paper was **Hickory.**

IV. Application.

The seedlings were planted out on November 4, 1952, and the interval between this date and the end of February, 1953 (approximately the end of harvesting) was divided into five or three periods as required for each treatment.

Dusts were applied by means of a hand rotary duster and sprays with a knapsack spray pump.

The amounts of both dusts and sprays used varied considerably, according to the age of the plants. The amounts of 50 per cent. lead arsenate dust varied between ½ to 2 lb. per treatment, 2 per cent. DDT dust from ½ to 3½ lb. per treatment and 0.1 per cent. DDT spray from 3 to 5 gals. per treatment.

V. Sampling.

This was carried out by examining all the leaves picked from the middle 20 plants of the middle row in each plot. Leaf miner damage was assessed by counting the number of leaf mines in each leaf. At the same time, chewing damage was estimated by placing the leaf into one of two classes—undamaged or slightly damaged and badly damaged.

VI. Results.

(i) *Leaf miner damage* (Table I).

The tabulated figures are the total number of leaf mines found in all the leaves from the 20 plants in each plot.

An analysis of variance was performed on the data. Since different numbers of leaves were taken from each plot, the variate used was the number of mines per leaf on a plot basis.

Examination of the results allows the following conclusions: —

(a) All the treatments were significantly better than the control.

(b) Treatment 4 (five applications of 2 per cent. DDT dust) was significantly better than both Treatments 2 and 3 (three and five applications of 50 per cent. lead arsenate dust), but Treatment 5 (three applications of 2 per cent. DDT dust) did not show significance from these treatments.

(c) Treatments 6 and 7 (0.1 per cent. DDT spray) were significantly better than Treatments 2 and 3 (lead arsenate dusts).

TABLE I.—LEAF MINES.

	Treatments.													
	1. Control.		2. 50% Lead Arsenate, 5 applications.		3. 50% Lead Arsenate, 3 applications.		4. 2% DDT. Dust, 5 applications.		5. 2% DDT. Dust, 3 applications.		6. 0·1% DDT. Spray, 5 applications.		7. 0·1% DDT. Sprav. 3 applications.	
	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.
Block A	202	338	186	261	242	326	148	102	249	294	298	76	282	180
Block B	136	150	169	243	274	219	329	114	237	327	270	61	337	195
Block C	130	403	217	222	213	247	321	202	432	91	272	45	330	47
Block D	267	705	201	105	182	303	348	56	131	77	535	216	190	98
Block E	300	682	254	362	240	390	287	133	187	237	263	52	291	87
Total all Blocks	1,035	2,278	1,027	1,193	1,151	1,485	1,433	607	1,236	1,026	1,638	450	1,430	607
Leaf mines per leaf	2·2010		1·1616		1·2902		0·4236		0·8301		0·2747		0·4245	
Treatment Totals Leaf mines/leaf	10·7899		5·8177		6·5958		2·2893		4·6262		1·2477		2·1741	

Least significant differences between 2 treatment totals.
At 5% level—2·9056
1% level—3·9494
0·1% level—5·2894

Fig. 1.—Tobacco bud showing serious budworm injury

(d) Treatment 6 (five applications of 0.1 per cent. DDT spray) was significantly better than Treatment 5 (three applications of 2 per cent. DDT dust). No significant difference was shown beween the other DDT treatments.

(ii) *Chewing damage* (Table II).

These results give the percentage of undamaged or slightly damaged leaves for each treatment. The treatments are tabulated in order of merit.

TABLE II.—CHEWING DAMAGE.

Treatment.	Total Number of Leaves.	Undamaged or Slightly Damaged.	Per cent. Undamaged or Slightly Damaged.
6	1,638	1,542	94·1
4	1,433	1,323	92·3
7	1,430	1,290	90·2
5	1,236	1,085	87·8
2	1,027	867	84·4
3	1,151	943	81·9
1	1,032	766	74·2

The differences in these percentages were tested firstly as a whole and then as individual comparisons using a chi-square analysis. The separate comparisons revealed a marked heterogeneity (see significant levels given in Table III).

The following conclusions can be made from the analysis:—

(a) All treatments were significantly better than the control.

(b) The DDT treatments (Treatments 4, 5, 6, and 7) were all significantly better than the lead arsenate treatments (Treatments 2 and 3).

(c) Treatment 6 (five applications of 0.1 per cent. DDT spray) was the best treatment followed by Treatment 4 (five applications of 2 per cent. DDT dust).

TABLE III.—CHEWING DAMAGE.

Significant Levels.

Treatments.	1	3	2	5	7	4	6
1		xxx	xxx	xxx	xxx	xxx	xxx
3			n.s.	xxx	xxx	xxx	xxx
2				x	xxx	xxx	xxx
5					x	xxx	xxx
7						x	xxx
4							x
6							

n.s. .... no significance.
x .... significant at 5% level.
xxx .... significant at 0·1% level.

VII. Discussion.

(i) *Leaf miner damage.*

From the results of this experiment, it can be seen that damage due to the leaf miner can be best controlled by the use of DDT either as a 2 per cent. dust or as a 0.1 per cent. spray. In all cases, DDT proved superior to the old method of control, namely the use of lead arsenate dust.

(ii) *Chewing damage.*

DDT was also proved to be superior for the control of chewing insects on tobacco in this experiment. The larger number of applications (5) of either DDT dust or 0.1 per cent. DDT spray was superior to the applications in each case.

(iii) *The experiment as a whole.*

The results from this experiment indicate that at the concentrations used, DDT either as a spray or as a dust is superior to lead arsenate dust to control insects damaging tobacco leaves in the field.

Thorough application of all treatments is most important and 3 to 5 gals. of spray were used to cover approximately 650 plants (19-32 gals./acre). With dusts, ½ to 3½ lb. were used (3-22 lb./acre), the amounts with either formulation varying with the size and development of the plants in each individual treatment.

Fig. 2.—A cutworm feeding on a young tobacco plant

EXPERIMENT 1953-54

Due to reports of the effectiveness of dieldrin against looper caterpillars on tobacco (Smith, 1953), and its known toxicity to grasshoppers, an experiment was begun during this season to compare dieldrin and the related compound aldrin with DDT. All three compounds were used in the form of sprays. Unfortunately, half way through the season, the site was converted to a dam and the experiment was abandoned.

EXPERIMENT 1954-55

The preceding season's experiment was repeated and, in addition, the promising new insecticide, endrin, was used. This material had been reported as effective against most tobacco pests (Smith, 1954). All three insecticides were compared with DDT against both the leaf miner and against leaf chewing insects.

I. Treatments.

From a survey of the literature, the following treatments were decided upon:—

(i) Control—no treatment.
(ii) 0.1 per cent. DDT.
(iii) 0.5 per cent. aldrin.
(iv) 0.1 per cent. aldrin.
(v) 0.05 per cent. dieldrin.
(vi) 0.1 per cent. dieldrin.
(vii) 0.05 per cent. endrin.
(viii) 0.1 per cent. endrin.

Experimental samples of aldrin, dieldrin and endrin were obtained from Shell Chemicals (Aust.).

All treatments were applied four times during the growing season—the first a week after planting out and the remainder at approximately monthly intervals.

II. Site.

As in the previous experiments, the site was at the Tobacco Research Station, Manjimup.

III. Design.

A randomised block design with four replications of eight treatments was used with plot sizes similar to those used in previous work.

IV. Application.

All treatments were applied with a knapsack spray pump. The amount of spray used varied from 2 to 4 gals. per treatment (16 to 48 gals. per acre).

TABLE IV.—LEAF MINES.

	Treatments.															
	1. Control.		2. 0·1% DDT.		3. 0·05% Aldrin.		4. 0·1% Aldrin.		5. 0·05% Dieldrin.		6. 0·1% Dieldrin.		7. 0·05% Endrin.		8. 0·1% Endrin.	
	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.	Leaves	Leaf. Mines.	Leaves.	Leaf Mines.	Leaves.	Leaf Mines.
Block A	189	771	300	114	163	404	153	212	228	294	273	173	161	137	231	101
Block B	323	632	301	134	318	180	251	159	294	171	238	229	256	124	188	159
Block C	182	476	333	63	232	136	237	106	255	165	235	125	225	90	173	30
Block D	226	353	260	255	224	358	234	316	223	453	221	120	260	286	222	151
Total all Blocks	920	2,232	1,194	586	937	1,078	875	793	1,000	1,083	967	647	902	637	814	441
Leaf mines per leaf	2·4261		0·4908		1·1505		0·9063		1·0830		0·6691		0·7062		0·5148	
Treatment Totals Leaf mines/leaf	10·2134		2·0552		5·2289		3·8168		4·5496		2·6708		2·8353		2·1365	

Least significant differences between 2 treatment totals.
At 5% level—3·2437
1% level—4·4134
0·1% level—5·9573

V. Sampling.

Sampling and the assessment of results were carried out in a similar manner to the previous experiments.

VI. Results.

(i) *Leaf miner damage—Table IV.*

While all treatments were significantly better than the control, there was no significant difference between individual treatments.

(ii) *Chewing damage—Table V.*

The results of individual comparisons between the treatments using a chi-square analysis are shown in Table VI.

TABLE V.—CHEWING DAMAGE.

Treatment.	Total Number of Leaves.	Undamaged or Slightly Damaged.	Per cent. Undamaged or Slightly Damaged.
2	1,194	1,076	90·4
6	967	819	84·9
4	875	676	77·4
5	1,000	771	77·2
8	814	629	77·0
3	937	705	75·6
7	902	638	70·2
1	920	369	39·1

The following conclusions can be made from the analysis:—

(a) All treatments were significantly better than the control.

(b) The best treatment was 0.1 per cent. DDT (treatment 2).

(c) 0.1 per cent. dieldrin (treatment 6) was superior to every treatment except DDT.

(d) Treatments 4 (0.1 per cent. aldrin), 5 (0.05 per cent. dieldrin), 8 (0.1 per cent. endrin) and 3 (0.05 per cent. aldrin) were not significantly different from one another.

TABLE VI.—CHEWING DAMAGE.

Significant Levels.

Treatments.	1	7	3	8	5	4	6	2
1		xxx	xxx	xxx	xxx	xxx	xxx	xxx
7			x	xx	xx	xx	xxx	xxx
3				n.s.	n.s.	n.s.	xxx	xxx
8					n.s.	n.s.	xxx	xxx
5						n.s.	xxx	xxx
4							xxx	xxx
6								xxx
2								

n.s. .... not significant.
x .... significant at 5% level.
xx .... significant at 1% level.
xxx .... significant at 0·1% level.

VII. Discussion.

The experiment has indicated clearly that good control of tobacco leaf miner in the field in Western Australia can be obtained with aldrin, dieldrin, endrin and DDT.

Fig. 3.—Looper caterpillar on leaf

Further, they all gave effective control of the chewing insects which damage tobacco at Manimup, Western Australia, but DDT spray at 0.1 per cent. strength and four applications throughout the growing season was the best treatment.

Endrin did not prove to be superior to DDT in Western Australia.

The relative importance of the chewing insects listed as attacking tobacco was not ascertained, but all were present at some stage of the experiment.

SCIENTIFIC NAMES

Leaf miner—*Gnorimoschema operculella* (Zell).

Cutworm, Budworm—*Heliothis punctigera* Wallengr.

Looper caterpillars—*Plusia* spp.

Grasshoppers—*Phaulacridium vittatum* (Sjost.). *Gastrimargus musicus* (F.). *Austroicetes vulgaris* (Sjost.).

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FARMERS

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Weight Trends in Fattening Cattle

Six Years' Trials at Wokalup Research Station

By M. CULLITY, B.Sc. (Agric.), Superintendent of Dairying

THIS work was commenced as part of the co-ordinated plan of investigations into beef growth rates in the southern regions of Australia, and was referred to in the introductory note "Beef Growth Rate Studies" published in this Journal (Vol. 5, No. 4, July-August, 1956). For the period 1950 to 1953 inclusive, an endeavour was made to procure evidence showing the trend in weight gain according to the seasons of the year. In the 1953-54 season and since, the work has been varied to measure the growth rate of steers which were grazed on irrigated pasture during the summer months, in comparison with others grazed on dry pasture at that time.

DESCRIPTION OF PROPERTY

The Wokalup Research Station is situated 91 miles from Perth on the main south-west highway. It comprises 2,200 acres on the foothills of the Darling Range and the coastal plain, and has approximately 750 acres under pasture. Its natural tree cover was red-gum and jarrah. Its initial development was commenced by a private owner approximately 100 years ago. The soils vary from heavy, medium and light clays adjacent to the foothills, to red and brown loams on the hill country with occasional granite outcrops. Some sandy loams occur on the flats. Some of the higher sections are lateritic. Deeper loams follow the gullies and good alluvial soils exist where these open on to the flats. The grazing areas with the exception of the irrigation paddocks, have a reasonable number of natural shade trees.

The climate is of the Mediterranean type, characterised by heavy winter falls with very dry summers. The distribution of the rain is shown in the histograms accompanying the graphs in this report. There are seasonal changes in the character of the pastures accompanying the climatic changes. The period of natural green grazing extends usually from April-May to November-December. A reasonable growth of pastures is obtained after the first autumn rains, but growth usually stops in July when the ground is very wet and cold. More rapid growth follows with the advent of the warmer days of spring, and maximum growth is obtained about the end of October with hay-cutting starting during the first or second week in November. In summer the herbage is dry, except on the flats at the foot of the hills, which contain a good deal of couch. The bulk from this, however, is not great unless a good fall of rain occurs, but then is available only for a limited period.

The pastures consist mainly of annual species including midseason subterranean clover (Mt. Barker), ryegrass, minor clovers such as suckling and cluster, with some medic, and minor grasses such as spear, barley and silver grasses. On the flats and some of the older paddocks, a couch base occurs which provides some green picking during the summer months. It is associated with perennial and annual ryegrasses in addition to the annual species already mentioned. In the hills some scrub areas were in each paddock. These are not taken into account in assessing stocking rates.

In describing the grazing by the stock in the various projects, the names of the paddocks will be given. The following key will assist in obtaining a ready knowledge of the constitution of the pasture.

Flats, Extended Flats, Windmill, Camp and Camdens paddocks all refer to the dry land pasture with a sole of couch.

Bull paddocks Nos. 1 and 2 are lower hill paddocks with a partial couch sole and less ryegrass than the flats.

Hills, Experimental, Camdens Hill, Fry's Hill, Burma Road—are generally similar to the pasture in the bull paddocks, but without couch and with a much lower proportion of ryegrasses than the flats.

Generally the carrying capacity of the paddocks under the general description of flats, was higher than those on the higher ground.

These dry land pastures produce a heavy bulk of green feed during the late winter to the early summer months and provide excellent dry grazing for the 3-4 dry months of the year. They are top-dressed annually with 2 cwts. of super-phosphate per acre.

The main south supply channel from the Stirling dam traverses the property, and commands approximately 250 acres suitable for irrigation. During the last three years, some 110 acres of high quality irrigated pastures have been established under the border system of irrigation. The species used include white and strawberry clovers with paspalum, cocksfoot, H.1. and perennial ryegrasses. These paddocks are watered during the summer months at three-weekly intervals with 4-5in. of water per acre. The first watering usually takes place in December and the last in March or early April. Superphosphate is applied twice per year, in autumn and in late spring at the rate of 2 cwts. per acre per application. Grazing is by cattle, and in summer, on a rotational system of strip grazing using an electric fence.

WEIGHING PROCEDURE

Weighing was carried out on a clock-face cattle weighbridge at intervals of 28 days. To allow identification of individuals and the progressive recording of their weights, all cattle were eartagged.

On weighing days cattle were mustered about 8.30 a.m. and weighing completed and the animals returned to grazing by about 10.30 a.m. Every endeavour was made to have the routine of mustering and weighing carried out in the same way each time.

Despite this however, environmental conditions varied and consequently the animals reactions in respect to grazing, watering, defecating, etc., varied with resultant influences on weight. The possibility of yarding all cattle overnight in order to have all in the same approximate degree of emptiness was considered as a means of removing some of the monthly variations, but as the establishment of trends of growth was the major objective, it was decided that the extra preciseness of individual weights would not warrant the additional discomfort for the stock or work for the staff. An examination of the tables for the average weights and weight movement at the end of this report will show several occasions when the recorded weight at a particular weighing was probably not the true weight owing to the animals being in a condition of relative emptiness when compared to other weighing dates. Quite frequently there were individual cases and occasionally with the group averages there has been an unexpectedly small increase in weight followed at the succeeding weighing by an apparent increase of about double that anticipated. The averaging of these gains gives frequently a curve of gradual trend.

SOURCES OF STOCK

The cattle were not selected specially for this study, but those which were readily available were used. The main supply was from those bred on the Research Station, and included a number of dairy steers in the early stages, and later the bulk were Poll Hereford-cross steers. These were the male progeny of a project in the grading up of a commercial Hereford herd from reject dairy cows. Two groups only were purchased outside the resources of Government farms, and not specifically for inclusion in this work, but to build up total stock numbers to utilise the abundance of feed. These groups were the 33 station-bred steers and the 40 mixed dairy steers both of Project 2.

Other importations on to the property were from the Pardelup Prison Farm, which was relieved of part of its surpluses, both of A.I.S. steers from its dairy herd and of Poll Hereford A.I.S. steers from a beef herd grading up project, using grade A.I.S. females and Poll Hereford bulls with

a similar objective to that at Wokalup. Poll Herefords were used exclusively and where the word Hereford appears in this report it should be read to mean Poll Hereford. Other A.I.S. steers were bred in the pure bred A.I.S. herd of the Claremont Mental Hospital. These were taken over when only a few days old and reared on milk substitutes at Wokalup.

PROJECT 1

Objective.

As outlined in the general introduction to the reports on beef growth trend investigations in this State—see Journal of Agriculture September-October, 1956—it was planned to gain knowledge of the movement in weight of cattle being fattened during the changing seasons of the year and under normal management. This means that no attempt was to be made to give the cattle in the study special attention or feeding. The basic preschedule prepared for all the centres throughout the Southern States envisaged the collection of data for a period of five years, without attempting to vary or improve management. However, owing to the recognised regular pattern of the climate in the West Australian agricultural areas, it was agreed that three years' data should be sufficient to fix reasonably accurately what might be considered the normal pattern of growth.

Beef type cattle were not available but sufficient dairy steers were on the property and it was decided to work with these. As it was planned to introduce cross-bred beef animals in following years, the opportunity would occur of comparing the growth trends to ascertain whether there were any differences due to breed or type, or whether movements in weight were a reflection of the feed intake.

Stock.

Thirty-five steers bred from dairy cows and reared on their dams, were selected. These comprised 15 Jersey, 13 Australian Illawarra Shorthorn, and 7 Guernsey. They were not pure-bred stock, but grade animals or crossbreds showing the characteristics of one or another of the above breeds. They were the progeny of reject dairy cows from a heifer-buying and mating scheme, operated after the war to provide cows for War Service Land Settlement farmers. Their ages varied at the commencement of weighing from approximately 15 months, to 2½ years.

Seasonal.

In the spring of 1950, grazing was prolonged slightly owing to rainfall being above average and extending to the end of November. After the dry months of summer, the opening rains of the next season fell in early April and annual pastures germinated about April 11-12. The remainder of 1951 followed a normal pattern, except for lighter than average rainfall in September, which had little adverse effect on the amount of herbage.

Grazing.

Grazing was carried out in various paddocks as under:—

October 30, 1950 to January 14, 1951—Oat crop and stubble.

January 14, 1951 to May 15, 1951—Hills.

May 15, 1951 to August 8, 1951—Hills and flats, alternatively at approximately weekly changes.

August 8, 1951 to October 25, 1951—Flats.

October 25, 1951 to January 17, 1952—Hills paddocks.

Stocking concentration for grazing varied from one beast per acre to one beast per two acres over the major part of the time. During the months of January to May of 1951, the stocking rate on the hills grazing was three acres per beast.

Growth Trends and Rates.

The growth curve in Fig. 1 shows two periods of rapid increase in weight from October 30, 1950, to December 19, 1950, and from May 15, 1951, to December 20, 1951. In the next three months weights were relatively static, followed by a substantial decline in weight in April of 1951.

The movements in weight for these periods were:—

From October 30, 1950 to December 19, the average weight increased by 105 lb. from 884 to 989 lb. or by 2.14 lb. per day.

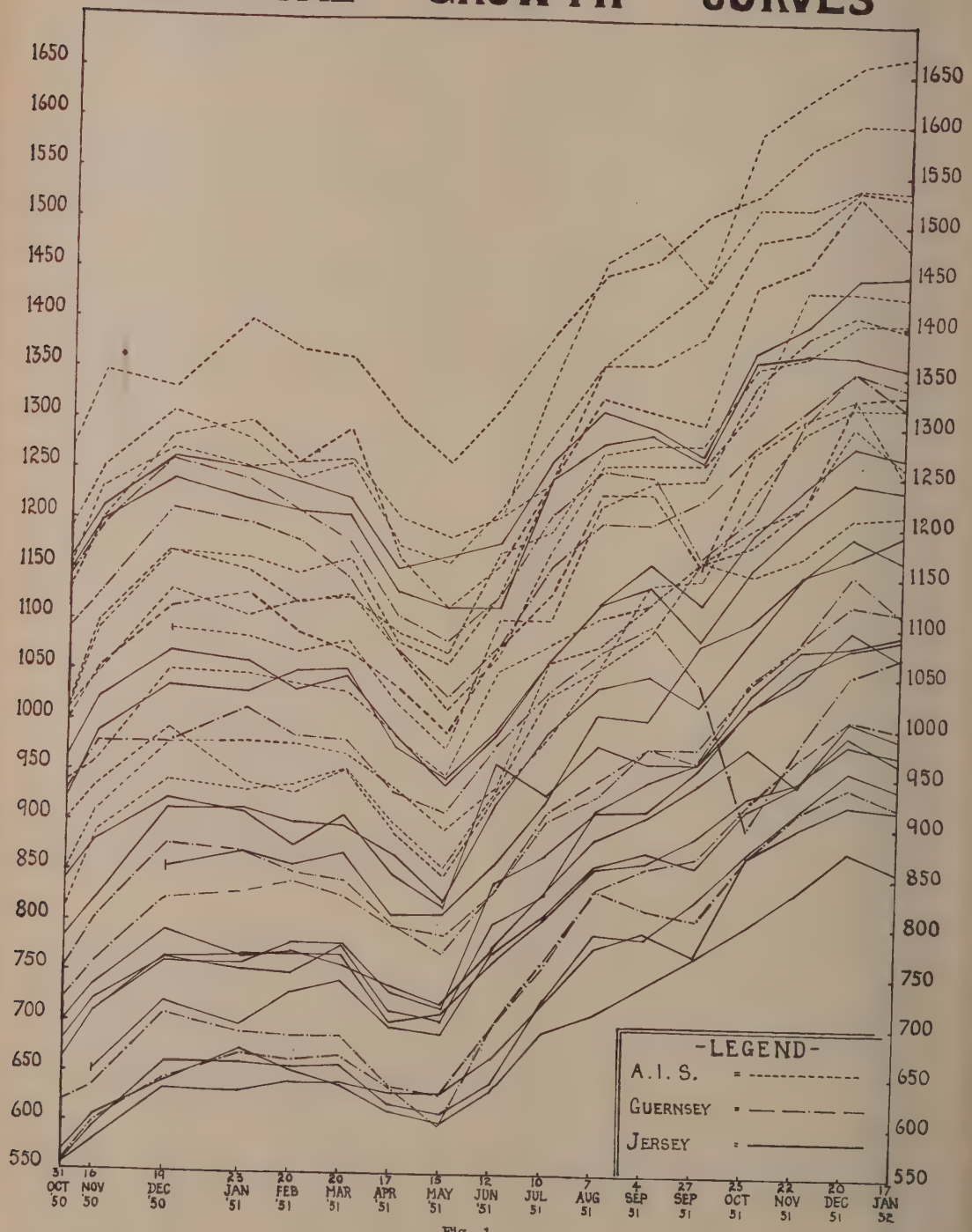
INDIVIDUAL GROWTH CURVES
1650
1600
1550
1500
1450
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
31 OCT '50
16 NOV '50
19 DEC '50
23 JAN '51
20 FEB '51
20 MAR '51
17 APR '51
15 MAY '51
12 JUN '51
10 JUL '51
7 AUG '51
4 SEP '51
27 SEP '51
25 OCT '51
22 NOV '51
20 DEC '51
17 JAN '52
-LEGEND-
A.I.S. =
GUERNSEY =
JERSEY =

Fig. 1

BREED AVERAGE — GROWTH CURVES

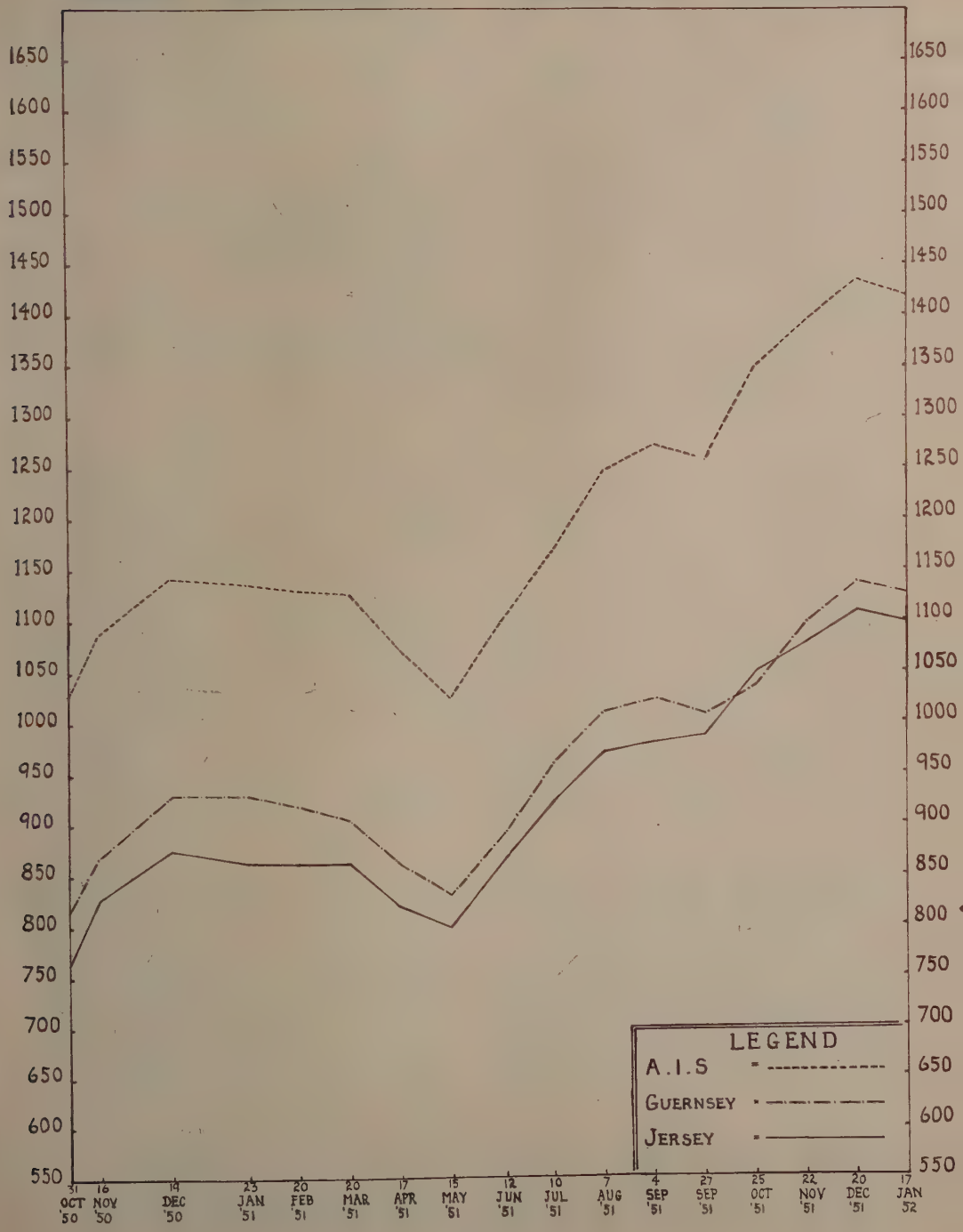

Fig. 2

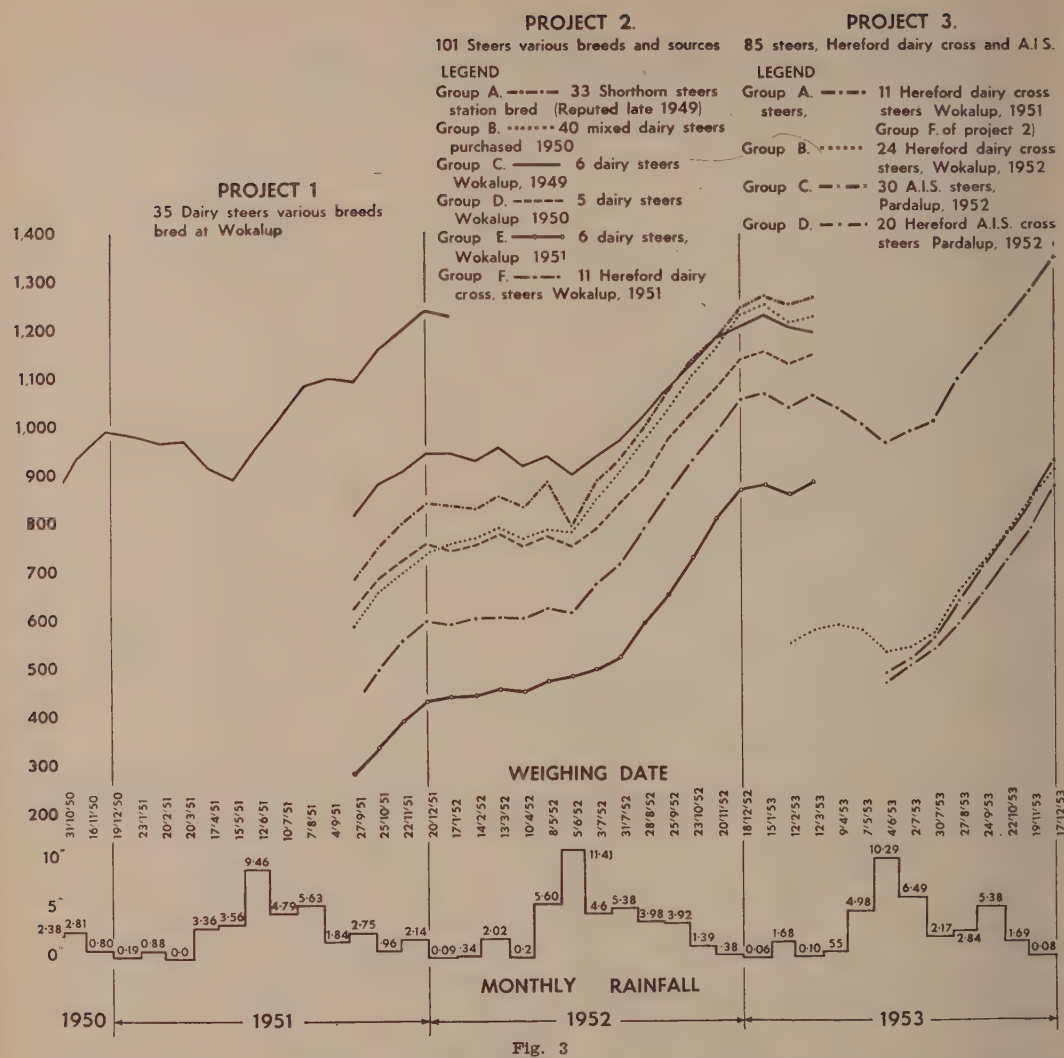
PROJECT 2.
101 Steers various breeds and sources
LEGEND
Group A. 33 Shorthorn steers station bred (Reputed late 1949)
Group B. 40 mixed dairy steers purchased 1950
Group C. 6 dairy steers Wokalup, 1949
Group D. 5 dairy steers Wokalup 1950
Group E. 6 dairy steers, Wokalup 1951
Group F. 11 Hereford dairy cross, steers Wokalup, 1951
PROJECT 3.
85 steers, Hereford dairy cross and A.I.S.
LEGEND
Group A. 11 Hereford dairy cross steers Wokalup, 1951 Group F. of project 2)
Group B. 24 Hereford dairy cross steers, Wokalup, 1952
Group C. 30 A.I.S. steers, Pardalup, 1952
Group D. 20 Hereford A.I.S. cross steers Pardalup, 1952
PROJECT 1
35 Dairy steers various breeds bred at Wokalup
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
WEIGHING DATE
31/10/50 16/11/50 19/12/50 23/1/51 20/2/51 20/3/51 17/4/51 15/5/51 12/6/51 10/7/51 7/8/51 4/9/51 27/9/51 25/10/51 22/11/51 20/12/51 17/1/52 14/2/52 13/3/52 10/4/52 8/5/52 5/6/52 3/7/52 31/7/52 28/8/52 25/9/52 23/10/52 20/11/52 18/12/52 15/1/53 12/2/53 12/3/53 9/4/53 7/5/53 4/6/53 2/7/53 30/7/53 27/8/53 24/9/53 22/10/53 19/11/53 17/12/53
10"
5"
0"
2·38 2·81 0·80 0·19 0·88 0·0 3·36 3·56 9·46 4·79 5·63 1·84 2·75 ·96 2·14 0·09 ·34 2·02 0·2 5·60 11·41 4·6 5·38 3·98 3·92 1·39 ·38 0·06 1·68 0·10 ·55 4·98 10·29 6·49 2·17 2·84 5·38 1·69 0·08
MONTHLY RAINFALL
1950
1951
1952
1953

Fig. 3

By May 15, 1951, however, it had declined to 889 lb., i.e. by 100 lb. or 0.67 lb. per day.

From then, however, they grew rapidly till they achieved their maximum weight at December 20, 1951, when they averaged 1,237 lb. The gain in the 219 days was 348 lb. or 1.59 lb. per day. By the next weighing on January 17, 1952, they had again lost weight to the extent of 11 lb.

Discussion.

The cattle in this project were a very mixed group. They were dairy steers of various breeds and crosses of breeds. They were all ages from yearlings up to nearly three-year-olds at the start. Over the period of these investigations, the trend in weight gain for all individuals irrespective of breed and age, was the same. Reference to Figs. 1 and 2 will show this. There appear to be differences in growth rate between the breeds and their crosses and at different ages—however no attempt can be made to measure if this were so owing to the lack of uniformity of the cattle within each breed or nominal breed cross.

One interesting feature of Fig. 1 is the decline in weight at the October, 1951, weighing. The cattle were dehorned about two or three weeks previous to this on

September 16, and although there was no apparent disturbance to the animals, it is of interest that at the following weighing, even though the feed and seasonal conditions were satisfactory, all animals showed a loss of weight. It cannot be stated precisely that this loss of weight was due to the dehorning, but the coincidence is reported.

An examination of the weighings prior to dehorning, suggests that possibly another abnormal but unknown influence was responsible. A setback at this period of the year was not expected, nor repeated in later trials.

The rate of growth of this Group of mixed dairy steers, was considered very satisfactory.

PROJECT 2

Objective.

As indicated in the objective of Project 1, the plan was primarily to collect data over a period of three years to establish a normal growth curve. The disposal of the animals from Project 1 necessitated the formation of new groups, and the opportunity was taken of including animals from various sources, while complying with the main aim of collecting data on growth trends, to demonstrate uniformity of response in the time of gaining and losing weight.

The inclusion of a group of station-bred Beef Shorthorns enabled the first attempt at the accumulation of data to compare the performance of beef and dairy steers.

Stock.

One hundred and five mixed steers were used from the following sources:—

(a) Thirty-three (33) station-bred Shorthorns born in late 1949 were purchased.

(b) Forty (40) steers of dairy breed, but predominantly Australian Illawarra Shorthorn, were purchased from local sources.

(c) Six of the original steers of Project 1 were retained. These included 2 grade Jerseys, 1 Guernsey, and 3 Jersey Cross Shorthorn. They were born in autumn 1949.

(d) Five (5) 1950 drop steers of which three (3) were predominantly Jersey and two (2) Guernsey. These were bred on the property, the progeny of cows sold to local dairymen.

(e) Six (6) 1951 drop grade dairy steers including four (4) Shorthorn, one (1) Jersey and one (1) Guernsey.

(f) From a project of grading up a commercial Hereford herd from a foundation of reject dairy cows, using polled Hereford bulls, eleven (11) steers born in 1951 were selected. Six (6) were from Jersey cows, three (3) were from cows of Friesian type, while one (1) each was from cows of Shorthorn and Guernsey type.

Seasonal.

This project extended from September 27, 1951, to March 12, 1953. The climatic characteristics meriting description were an unusually dry April when only 12 points of rain fell. The opening rains did not occur until the first week of May, and hence there was little green pasture available until June. The rainfall in June (11.41 inches) was well above average. July recorded 4.60 inches only, but the falls in August, September and October (5.38, 3.98 and 3.92 inches respectively), were very good, and resulted in particularly good growth of pasture throughout the spring, and a slightly longer grazing period before hay cutting.

From September 27 to October 26, the couch flats were used. For the following approximately three months till January 17, the cattle were kept on the hills, being returned to the flats again until February 14. Until May 8, they had free access to hill and flat pasture, thence to July 3 apart from one small section which alternated from flats to green oats and back, hill paddocks were used. 100 acres of green oats plus 20 acres of pasture were then used continuously till August 25. For the next five months to January 15, hill pasture with access to bush was available. Following that until March 12, flats were again grazed with some broken bales of hay left from hay making.

Growth Rates and Trends.

These groups were weighed for the first time on September 27, 1951, when the average weight was 599 lb., and continued under observation until March 12, 1953, when an average of 1,198 lb. was recorded. Over the whole of this period of 476 days, the average increase per beast was 599 lb. or 1.12 lb per day per beast. The maximum average weight however (1,211 lb.) was achieved on January 15, 1953.

Within this 105 head, it is possible to consider six groups, according to the sources or age of the cattle, as set out in the general description under "stock." The weight trend for these were as follows:—

(A) Thirty-three (33) steers from station-bred stock. Their weight at September 27, 1951, was 687 lb. They increased to 839 lb. by December 20, 1951, i.e. by 152 lb. or 1.81 lb. per day. From that date, there was little movement in weight until the following June. At June 5, the average weight was 794 lb. or 45 lb. less than at the December weighing. From June 5, 1952 to January 15, 1953, they gained 467 lb. or 2.12 lb. per beast per day. Recording continued until March 12, with no real variation in the weight.

(B) Forty (40) mixed dairy steers from South-Western sources. These gained 174 lb. or 2.1 lb. per day, from September 27, 1951 to December 20, when they weighed 758 lb. There was a very slight increase in weight to 780 lb. by June 5, From that date until January 15, 1953, a period of 224 days, they gained 470 lb. or 2.11 lb. per day to an average of 1,250 lb. A loss of weight amounting to an average of 22 lb. per beast occurred by the weighing on March 12, 1953.

(C) Six (6) dairy steers born in 1949 were carried over from Project 1. These were the heaviest animals in Project 2 weighing an average of 819 lb. on September 27, 1951. By December 20, 1951, they had gained 127 lb. but by the 5th of the following June they had declined to 904 lb., a loss of 42 lb. From June 5, 1952 to January 15, 1953, they gained 322 lb. or 1.44 lb. per beast per day, the average weight then being 1,226 lb. There was a slight falling off in weight amounting to 29 lb. by the March 12 weighing.

(D) Five (5) 1950 drop dairy steers. The commencing weight on September 27, was 623 lb. By December 20, this had risen to 755 lb. a gain of 132 lb. The weight at June 5, was 4 lb. less (751 lb.) but by January 15, 1953, the animals had gained an average of 408 lb. to 1,159 lb., or in the period of 224 days 1.82 lb. per day. A small loss of weight of 9 lb. occurred by March 12.

(E) Six (6) 1951 drop dairy steers. The weight trend in this group was a little different from the others, inasmuch as the animals continued to grow even at a slow rate during the summer and autumn months. They were very light at the start, but grew satisfactorily throughout. They gained from 289 lb. to 433 lb. from September 27 to December 20, 1951, and then rose slowly to 485 lb. on June 5, following. In the next 224 days to January 15, they gained 397 lb. or 1.77 lb. per beast per day. There was no loss of weight in the following two months.

(F) Eleven (11) Hereford dairy cross steers were calved 1951. These animals were weighed while still with their dams and their average weight on September 27, was 426 lb. They were weaned after the November weighing, when they recorded 561 lb., or a gain of 135 lb. in the two weighing periods (56 days). They continued to grow until December 20, when their average weight was 600 lb. They had put on 174 lb. in 84 days or 2.07 lb. per day. A further slight improvement in weight was recorded by June 5, 1952, when 614 lb. was

recorded. During the following 224 days to January 15, 1953, they grew at the average rate of 2.02 lb. per day, or an increase of 454 lb. for the period to a maxi-weight of 1,068 lb. There was only a very slight decline in weight by March 12, 1953.

Discussion.

The main objective of Project 2 was to continue the collection of data to establish what might be considered a normal growth curve for this district. The results of the trials show that there is no difference in the period during which weight increased or was lost, from that established in Project 1. The cattle grew rapidly during the winter and spring months, and maintained their weight for some months during the summer, and then lost weight in the autumn and early part of the winter.

There were six different groups of cattle obtained from various sources. No difference in the trend of weight gain could be detected as related to the source of cattle, nor to their type. Attempts were made to investigate the influence of feeding the animals on green oats, but after a short period this was discarded, as it was realised that the frequent changes of feed was having an adverse effect by causing scouring.

This, however, did not appear to have affected the overall trend for the season.

In this project there were a group of 33 station (North-west) bred Shorthorns. An examination of the weight movements showed that there was no difference in the trend in the gain of weight between these cattle and those from local sources.

A group of Hereford cross steers from dairy cows was also included, but again no difference in the periods when weight was gained and lost was recorded.

The rate of gain of the various sub-groups showed some differences.

For the whole period September 27, 1951, to January 15, 1953, a total of 476 days, the greatest weight increase was recorded by 40 dairy steers, from various sources, which gained 666 lb. or 1.40 lb. per day. The two actively growing periods, September 29, to December 20, 1951, and June 5, 1952 to January 15, 1953, showed gains of 174 lb. and 470 lb. respectively, or 2.1 per day during each period. The 11 Hereford dairy cross steers follow closely with 642 lb. in the 476 days, or 1.3 lb. per day. The gains during the two growing periods were 2.07 and 2.02 lb. per day respectively.

The next best performance was that of the station (North-west) bred steers with a gain of 583 lb. in the 476 days, and growing rates 1.8 lb. and 2.12 lb. for the two actively growing periods.

The lowest rate of growth is for the small group of six dairy steers from Project 1 which were kept until they were four years old. They gained 409 lb. only in the 476 days, and 1.5 and 1.44 lb. only in the two growing seasons.

The other groups of dairy steers were intermediate in their growth rates.

A study of the rate of gain shows that the group of beef strain was not clearly superior. One large group of dairy steers grew most rapidly of all, closely followed by a group of Hereford dairy cross steers, and they in turn by a group of Beef Shorthorns.

No carcase evaluations were possible.

PROJECT 3

Objective.

The disposal of the animals used in Project 2 enabled fresh groups to be formed to continue the study of growth trends in conformity with the basic pre-schedule. While this general study was in train, it was aimed also to continue studying the possible effect of source on trends and also, because of the inclusion of first-cross Hereford steers from dairy cows some of which were the dams of the steers in Project 1, to commence building up information comparing Hereford dairy cross steers with pure dairy steers.

Stock.

Eighty-five steers were used of which 30 were grade A.I.S. and 20 were Hereford X.A.I.S. transferred from the Pardelup farm. The remaining 35 were Hereford cross from cull dairy cows bred on the Research Station, and included 11 from Group (F) of Project 2.

The animals transferred from Pardelup were backward in growth and light in condition.

Seasonal.

The year 1953 in a general way followed the expected pattern. The season was not early as first germinating rains did not fall till May. June's rainfall of 10.29 inches was well above average, but was followed by below average falls and brighter weather than usual in July and August and September. At the end of September, prospects for the remainder of the year were not bright. However, good falls in October ensured an excellent finish to the spring period, both in respect to quantity of herbage and a slightly lengthened green grazing season. Conditions in November, December and January 1954, were normal.

Grazing.

The grazing history of the groups was as follows:—From January 15, 1953 to March 12, couch flat grazing was used. From then to May 7, dry hill pasture was made available. Until August 20, all the cattle were on hill pasture, but half received a small ration of hay. This was discontinued on August 20, but all remained on the hills until September 3.

They returned to this pasture from September 23 to October 16, and from October 28 to December 17. Otherwise till January 14, 1954, the couch flats were used.

Growth Rate and Trends.

The weights of the steers were recorded in the three sub-groups referred to above. A comparison with the feeding of hay in the autumn and winter was attempted, but discarded for reasons to be explained later.

Details of growth are as under:—

Group A was comprised of 11 Hereford dairy cross steers born on the Research Station in 1951. These were Group F Project 2. In the 12 months prior to reconstitution for this project they increased weight by 435 lb., being 1,040 lb. on February 12, 1953. By June 4, weights had declined by 71 lb. to 969 lb. They then grew continuously to January 14, 1954, achieving an average of 1,353 lb. or an increase of 384 lb. in that period. This was a gain of 1.7 lb. per day Weight then declined to 1,331 lb. on February 11, 1954, with a slight rise to 1,339 lb. at March 11.

Group B was made up of 24 Hereford dairy cross steers born on the Research Station in 1952. Their commencing weight on February 12, was 557 lb. from which they lost an average of 21 lb. to 536 lb. by June 4. They then grew continuously to January 14, putting on to a weight of 921 lb., a gain of 385 lb. or 1.7 lb. per day. The gain was the same as in the older cattle in Group A.

Group C thirty (30) Australian Illawarra Shorthorn steers ex the Pardelup Prison Farm were brought into the trial on June 4, 1953. They were yearlings, were light in condition, and averaged 494 lb. only. They grew continuously to January 14, 1954, and increased by 453 lb. to 947 lb. in the 224 days. This is equivalent to 2,02 lb. per beast per day. Further weighings were not carried out.

Group D contained (20) Hereford A.I.S. cross steers ex Pardelup Prison Farm. As with group (b), weighing commenced on June 4, when the animals averaged 475 lb. They grew in the 224 days until January 14, 1954, 417 lb. or 1.81 lb. per beast per day.

Supplementary Feeding with Hay.

An attempt was made to measure the effectiveness of feeding hay to a portion of the cattle. This comparison commenced on June 4, 1953, there being formed two groups, each containing 18 of Wokalup Hereford X, 10 Pardelup Hereford X and 15 Pardelup A.I.S. They were watched as closely as possible and the average weights were 536 lb. and 595 lb. respectively. The latter group were kept in a small paddock and fed 20 lb. meadow hay per day while the former were grazed in paddocks selected at the discretion of the manager. Comparisons were made for June and July only.

At the July 2 weighing, the relative weight movements were + 15.3 lb. (pasture), + 20.4 lb. (hay). At July 30 they were 46.7 lb. (pasture) and 33.7 lb. hay. An examination of the position indicated that owing to the hay group being kept in a restricted area, the quantity of pasture available quickly became very limited and the comparison then became one between free pasture and hay fed below normal requirements.

It could not be accepted as a test of supplementary feeding as the basic pastures for the two groups were dissimilar. From August 20, 1953, all the animals were run together. This attempted comparison does not invalidate the information gained on trends in the respective groups A. B. and C, as the animals were equally divided for the purpose of the supplementary feeding trial.

Discussion.

As indicated in the objectives for this project, the accumulation of data of growth rates in conformity with the basic preschedule continued and the results showed there was no change in the trend. The cattle gained and lost weight at the same periods of the year as in the earlier projects. An attempt was made to obtain some information regarding the value of supplementary feeding with hay, but owing to inability to provide sufficient pasture for separate groups, it was quickly found that the hay-supplemented cattle became a group which was receiving hay and little pasture instead of receiving pasture supplemented with hay. For this reason, the attempt was abandoned, and the separate sub-groups were eliminated. The abandonment of the attempt to accumulate data regarding the value of a hay supplement does not affect the collection of data showing the trend of growth over the year.

As with Project 2, there was no evidence to indicate any difference in the trend according to the source of the cattle. In this project were three groups of Hereford dairy cross steers bred at Wokalup and at Pardelup and also a group of graded up A.I.S. steers bred at Pardelup. In view of the importance of the latter breed as a source of cattle for fattening in the dairying districts of the south-west, a comparison with the Hereford cross is of special value and interest. A.I.S. steers grew more rapidly than Hereford dairy cross steers from two different sources. The details are as follows:—

In the 224 days from June 4, 1953 to January 14, 1954, Group A comprised of 1951-born steers, gained 384 lb. Group B—steers of similar breeding born one year later at Wokalup, gained 385 lb. Group C, 20 of the same cross, bred at the Pardelup Prison Farm in 1952, gained 417 lb. or 1.81 lb. per day, while the 30 A.I.S. steers (group D) bred at Pardelup gained 453 lb. or 2.02 lb. per day.

The two groups of Pardelup bred cattle grew more rapidly than those bred at Wokalup. Although the weights of the former before June 4, 1953, are not available, observation showed that they were in lighter condition than the latter, and their performance in making comparatively more rapid gains parallels the experience gained in other trials.

Group A lost 71 lb. from February 12 to June 4, while the younger Group B lost 21 lb. only. This experience has been repeated in other projects in these trials.

Project 1.

36 HERD DAIRY STEERS—VARIOUS BREEDS AND AGES.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
30–10–50	884	....	....
16–11–50	931	+47	+2·90
19–12–50	989	+58	+2·07
1–51	978	—11	—0·31
2–51	968	—10	—0·36
3–51	970	+ 2	+0·07
4–51	916	—54	—1·93
15–5–51	889	—27	—0·96
12–6–51	957	+68	+2·43
7–51	1,019	+62	+2·21
8–51	1,082	+63	+2·25
4–9–51	1,098	+16	+0·57
27–9–51	1,091	— 7	—0·03
10–51	1,157	+66	+2·36
11–51	1,197	+40	+1·43
20–12–51	1,237	+40	+1·43
1–52	1,226	—13	—0·46

Project 2.

105 HEAD (MIXED).

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
29–9–51	599	....	....
25–10–51	666	+67	+2·39
22–11–51	711	+45	+1·61
20–12–51	758	+47	+1·68
17–1–52	757	— 1	—0·04
14–2–52	763	+ 6	+0·21
13–3–52	779	+16	+0·57
10–4–52	764	—15	—0·54
8–5–52	792	+28	+1·0
5–6–52	756	—36	—1·29
3–7–52	826	+66	+2·36
31–7–52	873	+47	+1·68
28–8–52	940	+67	+2·39
25–9–52	1,014	+74	+2·64
23–10–52	1,076	+62	+2·21
20–11–52	1,121	+45	+1·61
18–12–52	1,192	+71	+2·54
15–1–53	1,211	+19	+0·68
12–2–53	1,184	—27	—0·96
12–3–53	1,198	+14	+0·5

Project 2 (Group A).
33 STATION BRED SH. CALVED 1949.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	687	....	....
25–10–51	754	+67	+2·39
22–11–51	797	+43	+1·54
20–12–51	839	+42	+1·50
17–1–52	838	— 1	—0·04
14–2–52	835	— 3	—0·11
13–3–52	858	+23	+0·82
10–4–52	834	—24	—0·86
8–5–52	888	+54	+1·93
5–6–52	794	—94	—3·36
3–7–52	888	+94	+3·36
31–7–52	936	+48	+1·71
28–8–52	1,001	+65	+2·32
25–9–52	1,077	+76	+2·71
23–10–52	1,138	+61	+2·18
20–11–52	1,186	+46	+1·64
18–12–52	1,248	+62	+2·21
15–1–53	1,270	+22	+0·79
12–2–53	1,251	—19	—0·68
12–3–53	1,268	+17	+0·61

Project 2 (Group B).
40 DAIRY STEERS.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	584	....	....
25–10–51	657	+73	+2·61
22–11–51	700	+43	+1·54
20–12–51	758	+58	+2·07
17–1–52	757	— 1	—0·04
14–2–52	770	+13	+0·46
13–3–52	792	+22	+0·79
10–4–52	771	—21	+0·75
8–5–52	786	+15	+0·54
5–6–52	780	— 6	—0·21
3–7–52	849	+69	+2·46
31–7–52	904	+55	+1·96
28–8–52	972	+68	+2·43
25–9–52	1,047	+75	+2·68
23–10–52	1,108	+61	+2·18
20–11–52	1,164	+56	+2·0
18–12–52	1,231	+67	+2·39
15–1–53	1,250	+19	+0·68
12–2–53	1,217	—33	—1·18
12–3–53	1,228	+11	+0·39

Project 2 (Group C).
6 DAIRY STEERS, 1949.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	819	....	....
25–10–51	877	+58	+2·07
22–11–51	909	+32	+1·14
20–12–51	946	+37	+1·32
17–1–52	947	+ 1	+0·04
14–2–52	929	—18	+0·64
13–3–52	958	+29	+1·04
10–4–52	919	+61	+2·18
8–5–52	937	+18	+0·64
5–6–52	904	—33	—1·17
3–7–52	937	+33	+1·17
31–7–52	969	+32	+1·14
28–8–52	1,017	+48	+1·71
25–9–52	1,081	+64	+2·29
23–10–52	1,126	+45	+1·61
20–11–52	1,189	+63	+2·25
18–12–52	1,210	+21	+0·75
15–1–53	1,226	+16	+0·57
12–2–53	1,202	—24	—0·86
12–3–53	1,197	— 5	—0·18

Project 2 (Group D).
5 DAIRY STEERS, 1950.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	623	....	....
25–10–51	688	+65	+2·32
22–11–51	724	+36	+1·29
20–12–51	755	+31	+1·11
17–1–52	746	— 9	—0·32
14–2–52	755	+ 9	+0·32
13–3–52	798	+43	+1·54
10–4–52	753	—45	—1·61
8–5–52	775	+22	+0·79
5–6–52	751	—24	—0·86
3–7–52	789	+38	+1·36
31–7–52	844	+55	+1·96
28–8–52	894	+50	+1·79
25–9–52	978	+84	+3·0
23–10–52	1,029	+51	+1·82
20–11–52	1,082	+53	+1·89
18–12–52	1,145	+63	+2·25
15–1–53	1,159	+14	+0·5
12–2–53	1,128	—31	—1·11
12–3–53	1,150	+22	+0·79

Project 2 (Group E).
6 DAIRY STEERS, 1951.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	289	....	....
25–10–51	344	+55	+1·96
22–11–51	398	+54	+1·93
20–12–51	433	+35	+1·25
17–1–52	441	+ 8	+0·29
14–2–52	449	+ 8	+0·29
13–3–52	461	+12	+0·43
10–4–52	457	— 4	—0·14
8–5–52	479	+22	+0·79
5–6–52	485	+ 6	+0·21
3–7–52	500	+15	+0·54
31–7–52	527	+27	+0·96
28–8–52	597	+70	+2·5
25–9–52	659	+62	+2·21
23–10–52	734	+75	+2·68
20–11–52	812	+78	+2·79
18–12–52	868	+56	+2·0
15–1–53	882	+14	+0·5
12–2–53	869	—13	—0·46
12–3–53	881	+12	+0·43

Project 2 (Group F).
11 HEREFORD CROSS STEERS, 1951.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
27–9–51	426	....	....
25–10–51	504	+78	+2·79
22–11–51	561	+57	+1·04
20–12–51	600	+39	+1·39
17–1–52	595	— 5	—0·18
14–2–52	605	+10	+0·36
13–3–52	554	—51	+1·82
10–4–52	607	+53	+1·89
8–5–52	629	+22	+0·79
5–6–52	614	—15	—0·54
3–7–52	679	+65	+2·32
31–7–52	719	+40	+1·43
28–8–52	792	+73	+2·61
25–9–52	864	+72	+2·61
23–10–52	937	+73	+2·64
20–11–52	992	+55	+1·96
18–12–52	1,055	+63	+2·25
15–1–53	1,068	+13	+0·46
12–2–53	1,040	—28	+1·0
12–3–53	1,064	+24	+0·86

Project 3 (Group A (Group F of Project 2)).

11 HEREFORD CROSS STEERS BORN 1951 (WOKALUP).

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
12–2–53	1,040	....	....
12–3–53	1,064	+24	+0·86
9–4–53	1,030	—34	—1·21
7–5–53	1,003	—27	—0·96
4–6–53	969	—34	—1·21
2–7–53	996	+27	+0·96
30–7–53	1,011	+15	+0·54
27–8–53	1,101	+90	+3·21
24–9–53	1,160	+59	+2·11
22–10–53	1,225	+65	+2·32
19–11–53	1,284	+59	+2·11
17–12–53	1,351	+67	+2·39
14–1–54	1,353	+ 2	+0·07
11–2–54	1,331	—23	—6·82
11–3–54	1,339	+ 8	+0·29

Project 3 (Group B).

24 HEREFORD CROSS STEERS BORN 1952 (WOKALUP).

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
12–2–53	557	....	....
12–3–53	580	+27	+6·82
9–4–53	590	+10	+0·36
7–5–53	572	—18	—0·64
4–6–53	536	—36	—1·28
2–7–53	543	+ 7	+0·25
30–7–53	578	+35	+1·25
27–8–53	660	+82	+2·94
24–9–53	715	+55	+1·96
22–10–53	781	+66	+2·36
19–11–53	850	+69	+2·46
17–12–53	912	+62	+2·21
14–1–54	921	+ 9	+0·32
11–2–54	904	—17	—0·61
11–3–54	938	+34	+1·21

Project 3 (Group C).

30 A.I.S. STEERS X PARDALUP.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
4–6–53	494	....	....
2–7–53	518	+24	+0·86
30–7–53	567	+39	+1·39
27–8–53	646	+79	+2·82
24–9–53	707	+61	+2·18
22–10–53	782	+75	+2·68
19–11–53	850	+68	+2·43
17–12–53	936	+86	+3·07
14–1–54	947	+11	+0·39

Project 3 (Group D).

20 HEREFORD CROSS STEERS X PARDALUP.

Date.	Weight Average.	Change of Weight since Previous Weighing.	
		Total Change.	Average per Day.
	lb.	± lb.	± lb.
4–6–53	475	....	....
2–7–53	503	+28	+1·0
30–7–53	541	+38	+1·36
27–8–53	598	+57	+2·04
24–9–53	655	+57	+2·04
22–10–53	725	+70	+2·5
19–11–53	789	+64	+2·29
17–12–53	879	+90	+3·21
14–1–54	892	+13	+0·46

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The MANNA WATTLE (*Acacia microbotrya* Benth)

By C. A. GARDNER, Government Botanist

THE Manna Wattle is an attractive native tree which is worthy of attention for several reasons. Perhaps it is best known as the source of "manna gum"—the market value of which has risen from £170 per ton in 1955 to £252 per ton (2s. 3d. per lb.) at the present time.

Apart from the yield of gum however, the tree is both decorative and useful when used to provide windbreaks or shade for stock. It is eminently suitable for planting in areas with an annual rainfall between 12 and 20 inches, and its sweetly-scented blossoms, which usually appear in May and June, may some day have commercial value for use in the manufacture of perfume.

In the early days of settlement the bark of the Manna Wattle was often used in home tanning, and the gum was collected for export. Gum prices remained low however until the period following World War I.

Like the other wattles, the tree is not long-lived, but specimens should survive for from 20 to 30 years under most conditions.

Plants are available from the Forests Department nurseries at a cost of 24s. a dozen or 2s. 3d. a plant. Planting should be carried out as soon as possible after the commencement of the winter rains.

DISTRIBUTION

The tree was formerly common in the districts around Toodyay, Northam, York and Beverley and eastward to Merredin, and it extends from the Murchison River to the vicinity of Gnowangerup.

The Manna Wattle does not occur on the Western Coastal Plain and the nearest specimens to Perth are to be found on the Northam road between Clackline and Baker's Hill.

As in the case of sandalwood, the number of trees has been radically reduced owing to farming operations, but many still exist in uncleared areas within the general distribution range of the species.

DESCRIPTION

The Manna Wattle is usually a small, bushy tree about 10 to 16 feet tall, with widely-spreading branches. Much larger specimens were reported from the Dandarragan district about 1850 by Drummond, but these appear to be no longer in existence. The bark of the trunk is dark grey or almost black, rough and fibrous, and longitudinally fissured; that of the branchlets is smooth and greyish-green.

The foliage is spreading or pendulous, and the leaf varies in shape from narrow-lance-shaped to broad-lance-shaped, much narrower towards the stalk end, and usually three to five inches in length.

The leaf is usually broadest at or above the middle, a grey-green in colour, with a fairly prominent midrib and veined from this midrib with rather faint spreading veins. When narrow the leaf is somewhat sickle-shaped (i.e. curved to one side). The flowers are small in small round heads, these flower-heads being arranged in clusters along a common stalk up to one and a half inches in length. In other words, the flower heads or "balls" are not solitary, but several "balls" are arranged on a stalk from the point where the leaves emerge from the twig. This fact, together with the single vein down the middle of the leaf, the small flowers, and the flowering season (late April to mid-June) serve to identify the tree in the bush. Further, the plant occurs most frequently in jam-tree country, or occasionally with wandoo, and still less frequently with jam and salmon-gum.

The gum is exuded by the plants at various times of the year, especially in late summer and autumn and to a less

MANNA WATTLE (*Acacia microbotrya* Benth)

A—Branchlet showing foliage and flowers; B—Flower head; C—Flower (A—stamens, P—petals, K—calyx)

extent in the spring. It appears externally on the trunk and branches in the form of "tears" or large lumps (sometimes the size of a hen egg) varying in colour from a clear pale yellow to almost red. The red colour is due to tannis which discolour the gum as it passes through the bark, and, as a general rule, the clearer gum is obtained from the smooth upper bark, but is not as prolific there as on the rough bark of the trunk and main branches. As the gum exudes, the lumps increase in size and these are sometimes dissolved by the winter rains, when the substance becomes still more discoloured, and eventually reaches the soil as a deep red substance. In dry weather the gum crystallises externally, and may become powdery, while under spring and autumn conditions, especially where protected from the sun, the lumps remain smooth, and break with a clean fracture. It is these smooth lumps of gum which are the most valuable, and the gum when collected should always be free from pieces of bark.

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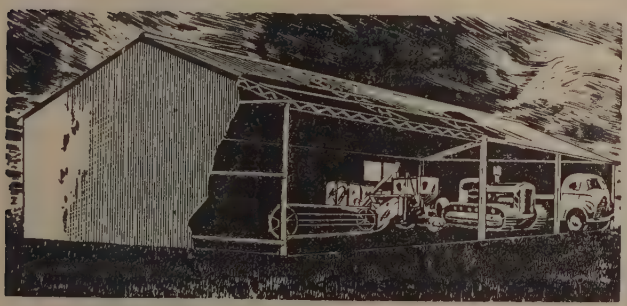

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PLANT DISEASES

STONY PIT OF PEARS

By H. L. HARVEY, B.Sc. (Agric.) Senior Plant Pathologist

STONY pit, a virus disease of pears, has been found in a number of districts in Western Australia, the first case having been noted in 1945. Descriptions of pear abormalities found in old records suggest that the disease was present 30 years ago.

SYMPTOMS

Affected fruits show surface pitting and general malformation (Fig. 1). The worst affected fruits are barely recognisable as pears and are very much reduced in size, while others show only a few pits and retain an almost normal shape and size.

On an affected tree, all degrees of pitting may be seen and some fruits appear to be quite normal. In the flesh beneath the pits, discolored areas ranging from green to brown may be seen if the surface layers of the fruit are cut away (Fig. 2). Hard stone cells occur in these areas and

Fig. 1.—Packham's Triumph pear (left) and Josephine pear (right) showing pitting and malformation due to the Stony Pit virus disease.

Fig. 2.—Packham's Triumph pear with surface cut away to show brown discoloured areas beneath surface pits. At an earlier stage these areas were pale green.

these, together with other undesirable fruit characteristics, make affected pears unpalatable and generally unsaleable.

On the trunks of old affected trees, a pattern resembling that on oak trees may occur, due to cracking of the bark. The name "oak-bark" has been applied to this symptom (Fig. 3) which may extend up from the trunk on to the main branches.

Leaf mottling and flecking has been observed on some affected trees but there is no certainity that this condition is due to the stony pit virus.

OCCURRENCE AND IMPORTANCE

From observations to date, the disease has only been found in three districts. Infected Josephines have been found at Mundaring and Argyle and infected Packham's Triumph, at Mundaring and Bridgetown. The percentage of infected trees was low.

As a number of pear varieties have been found to be susceptible to the disease in other parts of the world, further surveys may show more of our varieties to be infected with stony pit.

TRANSMISSION

It is by budding or grafting during propagation that the stony pit virus is transmitted in practice. That is, if the scion or rootstock come from infected sources, there is every risk that the progeny will be infected. This does not apply to seedling rootstocks as the virus is rarely if ever transmitted by means of seed.

No other means of transmission are known to occur in the nursery or orchard.

CONTROL

Pear tree propagation from scion and rootstock parents known to be free of the

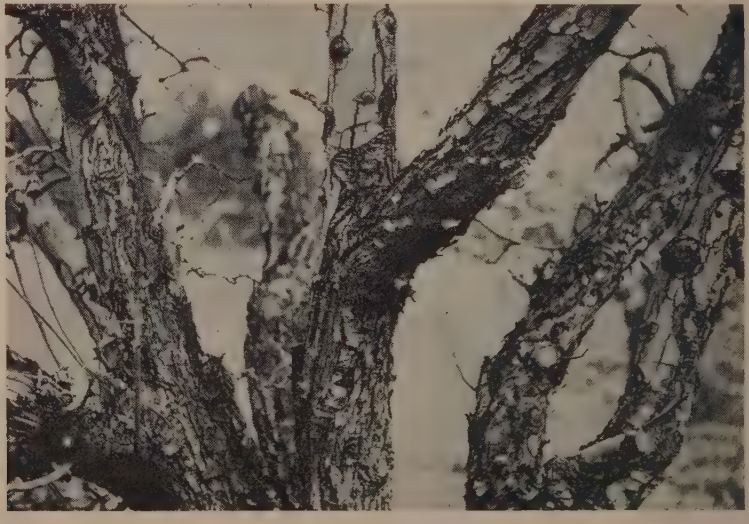

Fig. 3.—"Oak-bark" on the main limbs of a Josephine pear tree infected with stony pit.

stony pit virus, is the only way of avoiding the disease. There is no treatment that will cure trees which are already infected.

Working infected trees over to resistant or tolerant varieties cannot be recommended at this stage because the reactions of pear varieties to the disease, under local conditions, has not yet been determined.

It is fortunate that the incidence of this serious disease is still low in Western Australia. The use of trees propagated only from virus-free parents, will ensure that new plantings will be free of the disease and will aid also in a gradual elimination of stony pit as diseased trees are replaced.

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GLYCERINE *for* PREGNANCY TOXAEMIA . . .

By F. C. WILKINSON, B.V.Sc., Government Veterinary Surgeon

A DAILY dose of 4 to 6 oz. of glycerine mixed with an equal quantity of water and given as a drench will often cure pregnancy toxaemia ("twin lamb disease") especially if given as soon as the earliest symptoms are observed.

Recent research work has shown that pregnancy toxaemia is primarily a brain disorder, caused by a decrease in the quantity of blood sugar supplied to the brain.

The blood sugar level of ewes that are heavy in lamb falls rapidly if they are starved or underfed, even for short periods. If it falls to such an extent that the amount of sugar reaching the brain in the blood-stream is insufficient for the proper working of that organ, the brain is affected and may sustain permanent damage.

SYMPTOMS

The portions of the brain which are responsible for preserving "consciousness" have the greatest sugar needs and are the first to be affected.

Consequently, in the early stages of the disease, affected ewes appear "dopey"—dull and dazed, usually separating from the flock and moving slowly and aimlessly.

In this condition they may be approached or even touched before making any attempt to move away.

If driven, they move with a stiff unsteady gait and may fall down and be unable to rise without assistance.

Complete or partial blindness, grinding of the teeth and a thick mucous discharge from the nostrils are other common symptoms.

At more advanced stages of the disorder, the ewes go down and remain in a comatose condition until death occurs.

TREATMENT

The treatment aims to raise the blood sugar level to normal or above normal and to maintain it at a high level for some time.

Four to six ounces of glycerine with an equal quantity of water should be given as a drench every day until the symptoms disappear.

If treatment is commenced while the sheep is still able to stand there may be about 90 per cent. recovery.

If the animal is down and unable to rise, it has usually been affected for five or six days and the brain may have suffered irreparable damage.

If the animal is down in the normal position—on the breast—it will have a better chance of recovery than if it is lying on its side with legs outstretched.

Gentle handling in treatment is essential especially when drenching sheep, as it is quite easy under these circumstances for the drench to reach the lungs and so cause pneumonia.

The treated animals should be provided with readily available shade and water and when back on to their feed, plenty of easily digestible carbohydrate such as cereal grains must be available to maintain the blood sugar at the normal level. Care must be taken, however, where cereal grains are continuously available, as some animals may consume excessive amounts, which can lead to digestive disorders.

Where the disease occurs on good feed and there appear to be no obvious predisposing causes, driving for half an hour a day may help to reduce the incidence. The exercise helps to raise the blood sugar level for a sufficient time to enable the sheep to come back on to their feed.

Consequently, once pregnancy toxaemia is known to occur in the flock, ewes in the last month of pregnancy should be constantly watched for early symptoms. If treatment with glycerine is undertaken immediately these symptoms are shown, losses from pregnancy toxaemia will either be eliminated or reduced to a minimum.

The symptoms, predisposing factors, preventive measures and other information concerning pregnancy toxaemia of ewes were contained in an article which appeared in "The Journal of Agriculture of Western Australia" of May-June, 1954. This article was reprinted and is available as Bulletin No. 2162 which may be obtained free of charge from the Department of Agriculture, Perth.

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PHOTOSENSITISATION

by

H. W. BENNETTS, D.V.Sc.,

Principal, Animal Health and

Nutrition Laboratory

Fig. 1.—Swelling of the skin on a sheep's face and ears, due to photosensitisation
From Onderstepoort Jnl.

PHOTOSENSITISATION is a type of sunburn. It results from the presence of certain foreign pigments in the skin, making it unusually sensitive to the effects of light (photosensitive); exposure to sunlight then results in a more or less severe inflammation of the skin (photosensitisation).

The parts affected are those white or lightly coloured areas which are not well protected by hair or wool, and which are most exposed to light.

PLANTS RESPONSIBLE

There are a few plants that contain pigments, not usually encountered in the diet of the animal, which are absorbed by the gut and finally reach the skin causing it to become photosensitive. Notable examples are St. John's wort *(Hypericum perforatum)* and buckwheat *(Fagopyrum esculentum)*, both of which contain red pigments. Photosensitisation following the eating of these plants is well known, but neither plant occurs here.

On the other hand, the normal green colouring matter of plants, chlorophyll, may quite commonly give rise to photosensitisation under certain circumstances. During the process of digestion chlorophyll is changed into another pigment (phylloerythrin) which is an active sensitising agent. In the normal healthy animal phylloerythrin is excreted by the liver and does no harm. If, however, the liver is damaged by disease or by poisons

it is unable to carry out this normal function; the phylloerythrin then accumulates in the blood stream, is carried to the skin and sensitises it.

This is what happens in facial eczema, a serious disease which has been common in New Zealand on pastures dominated by ryegrass (*Lolium perenne*); the cause of the liver damage in this case has not been difinitely determined but is belived to be a toxic principle, sometimes present in the ryegrass. In this State we have not uncommonly seen photosensitisation following liver damage from toxic plants:—"rattlepod" (*Crotalaria retusa*) the cause of Kimberley horse disease, lupins (*Lupinus varius* and *L. angustifolius*) and in one instance from wild radish (*Raphanus raphanistrum*). Other plants occurring here which are known to produce liver damage followed by photosensitisation are the caltrop (*Tribulus terrestris*), lantana (*Lantana camara*) and heliotrope (*Heliotropium europaeum.)*

In Western Australia photosensitisation is not common; most outbreaks have been in stock grazing on burr clover (*Medicago denticulata*), subterranean clover (*Trifolium subterraneum*), or on lush mixed pastures. The mechanism of the photosensitisation in these cases is not clearly understood. The outbreaks frequently occur when green feed first comes away in quantity after a dry spell. This observation led Bignold (1946) to suggest that under these circumstances the liver is temporarily unable to deal with all the phylloerythrin absorbed from the pasture; there being no apparent liver damage.

OTHER CAUSES

Photosensitisation may also occur in poisoning with the following:—copper, phosphorus, carbon tetrachloride and phenothiazine. In certain rare disease conditions the production of abnormal pigments by the animal's own tissues may result in sensitivity to light (e.g. congential porphyria in cattle). There is a congenital photosensitivity in Southdowns which results from an inherited derangement of the mechanism of phylloerythrin excretion by the liver; the organ shows no structural abnormality in these cases.

The above conditions are of more theoretical than economic interest to us here.

Fig. 2.—Sheep suffering from photosensitisation flinching in sunlight
From Onderstepoort Jnl.

ANIMALS SUSCEPTIBLE

Cattle, sheep, horses, goats and pigs are known to be susceptible, as well as some experimental animals and man.

Friesian and Guernsey cattle, which have white patches, are often affected. Other breeds may show lesions on the udder and muzzle.

White-faced sheep commonly suffer, and all sheep are susceptible after shearing.

In horses the "blaze" down the face is often scalded, as well as the body patches on piebalds and skewbalds.

Pigs are rarely affected, only one outbreak being recorded, in Large Whites.

CONDITIONS UNDER WHICH PHOTOSENSITISATION OCCURS

A great amount of work has been and is being done on the climatic, meteorological and pasture conditions under which losses occur. From a consideration of the causes, as outlined, it is evident that outbreaks are most likely to occur after the first rains, when greenfeed becomes available. The disease is seen here from June to September in most years.

If the liver is already damaged from the previous eating of non-lethal amounts of certain toxic plants, greenfeed plus sunlight may be expected to produce trouble at any time of the year.

As indicated, a great variety of plants has been associated with the occurrence of photosensitisation. In some cases, how-

Fig. 3.—Sloughing of skin from the white portions of a Friesian heifer—a common result of photosensitisation

ever, the source of the trouble cannot be determined. It would appear that under suitable conditions, not yet fully understood, practically any green plant can produce the disease.

SYMPTOMS

Sheep.

The animals first stamp their feet, shake the head and move about restlessly. The head is rubbed against fences. Pain may be so severe that the animal becomes violent and frantic. If the back is affected, as in shorn sheep, the animal flinches and crouches down.

Shade is sought, the head being thrust into bushes, or against fence posts or against other sheep.

Then, swelling of the affected skin appears, the ears thicken and droop, and the eyelids, face and lips enlarge. Such an appearance may be confused with swelled head in rams (see this Journal, September, 1945), but the latter condition is usually confined to rams and is invariably fatal.

Clear straw-coloured fluid oozes from the affected surfaces, and crusts form. Rubbing of the part may cause abrasions. The ears shrivel.

In a few days the superficial layers of skin become dead and dry, and separate from the underlying layers. These are thereby protected from further damage and the irritation subsides. In two or three weeks the necrotic (dead) layers of skin peel off, leaving the new skin from which hair and wool grow again.

If the conditions are still suitable, a further scalding of the same area may occur.

These changes may or may not be accompanied by jaundice. If this condition is present, the mucous membrane of the of the eye will be tinged yellow.

There is severe loss of condition and in some cases death.

Cattle.

The symptoms are much like those in sheep. There is a sudden drop in milk yield, and the cow licks the affected parts, which include the udder, escutcheon, muzzle, eyelids and any white areas. Irritation is apparently less severe than in sheep.

Fig. 4.—Photosensitisation has caused lesions on the white areas of this skewbald horse (Undalls Vet. Medicine.)

The lesions are remarkably discrete; for example a strip of white only half an inch wide may peel off leaving the surrounding dark skin unaffected.

If the udder is badly burnt, severe mastitis may supervene.

Jaundice may or may not be present.

Figure 3 shows a denuded area with the sloughed skin still hanging to the leg by a few hairs. The new skin is still covered by a scab.

Horses.

In horses the symptoms are much like those seen in cattle.

POST MORTEM

Animals dying or killed while suffering from photosensitisation show the skin changes just described. Also, in cases where liver damage has occurred, this organ is found to be tough, fibrous and in old cases shrunken. The surfaces are finely mottled (as in a normal pig's liver) and often green or yellow-green in colour.

If liver changes have occurred, jaundice will also be present, the tissues of the body generally being more or less coloured by the yellow bile pigments.

TREATMENT

Suitable treatment will be obvious from a consideration of the cause. Any of the following measures alone or together, will be effective.

Shade.—Light from the sky as well as sunshine can cause irritation, hence tall trees do not give protection. Sheep and cattle may be confined in shearing sheds or barns in the day time and allowed to graze at night.

Dry Feed.—The trouble will subside if green feed can be removed from the diet.

Protective Paints.—In small outbreaks it may be found convenient to use a protective paint. Any dark coloured application may be used, which will not irritate the skin, damage the wool, be washed out by rain or be poisonous to an animal licking it.

A strong solution of Condy's crystals, which darkens the hair or wool after drying, is suitable in many cases.

PREVENTION

As the onset of the disease is usually sudden and often unpredictable, preventive measures are not very practical. The owner should be prepared to adopt suitable treatment at the first sign of the trouble.

REFERENCE

Bignold, B. (1945).—J. Dept. Agric. West. Aust., 22: 317.

Strains of Subterranean Clover *in* Western Australia

By B. J. QUINLIVAN, B.A., B.Sc. (Agric.), Botanist, Weeds and Seeds Branch

THE use of subterranean clover as a pasture plant in Australia dates back to 1889, for it was then that A. W. Howard, at Mt. Barker, in South Australia, recognised its value. However, despite his efforts to popularise the use of this clover, it remained unappreciated for many years. The first sale of commercial seed took place in 1906, but the area sown to subterranean clover showed no upward trend until 1920.

Subterranean clover was introduced to Western Australia as an impurity in other agricultural seed, about the year 1890 and by 1900 it was being cultivated in the Bridgetown district.

Mr. A. B. Adams of the W.A. Department of Agriculture was the first to record the presence of strains in subterranean clover in Western Australia (1).

By 1924 he had separated three distinct types—

(i) "Early" Dwalganup strain from Boyup Brook.

(ii) "Midseason" Mt. Barker strain from South Australia, and the

(iii) "Late" Wenijup strain from Bridgetown.

By 1940, however, Aitken and Drake were able to list a total of 50 separate strains growing under trial in Victoria (2).

Since then the number has been added to considerably. A total of 24 strains are known to be growing under natural field conditions in this State, 12 of which have been located since 1940.

THE ORIGIN OF THE STRAINS

Evidence as to the origin of strains is difficult to obtain. The normally accepted explanation for the development of distinct strains of cross-pollinated plants is that the environmental factor operates on a mixed genetic population following cross-pollination, natural selection takes place and strains adapted to the particular environment are produced. This process would not apply to any degree to subterranean clover which is a self-fertilised plant.

The plant itself occurs naturally over the whole of Southern Europe and North Africa; it is also recorded from England and Germany. In its natural habitat a considerable variation within the species has been recorded. Many of the strains recognisable in Europe are similar in major characteristics to Australian strains.

Subterranean clover strains have shown a remarkable lack of variation in botanical characteristics even when grown mixed with other strains over a number of years.

Bud mutations are known to have occurred. The "white-seeded" Dwalganup strain, which is a common impurity in the normal stands of Dwalganup is known to have arisen in this manner. Plants of the normal black-seeded Dwalganup have been located, which have one burr containing white seeds. These white seeds have bred true to type the following season.

Although the origin of the majority of the Australian strains can be traced back to their counterparts in Europe, the possibility of new strains arising, as a result

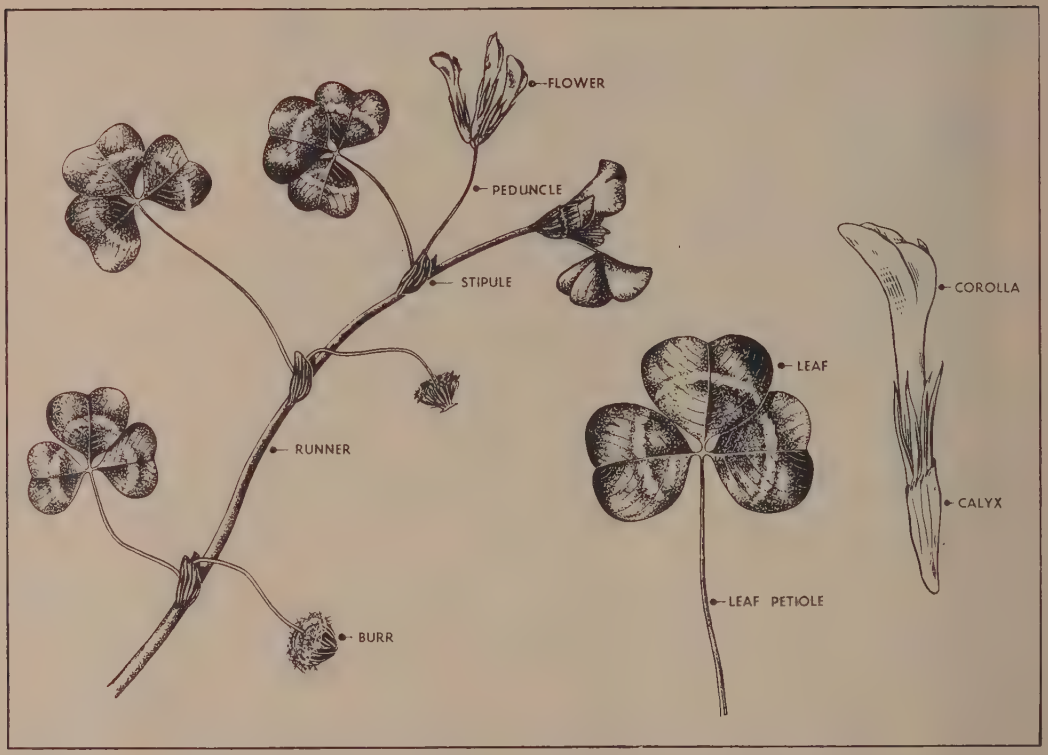


Fig. 1.—Drawing showing the meaning of botanical terms used in this article.

of natural cross-pollination under field conditions, cannot be ruled out altogether. Although there is no direct evidence, instances of new intermediate types being found in paddocks containing mixed strains are known. In a pasture at Manjimup two strains of clover have been growing mixed together for a number of years. They are the Mt. Barker strain with a hairy runner and red-banded calyx and the Pearsons strain with a hairless runner and white calyx. Over the last two years two intermediate forms have appeared, one with a hairy runner and a white calyx and the other with a hairless runner and a red-banded calyx.

STRAINS OCCURRING NATURALLY IN WESTERN AUSTRALIA

The majority of the certified commercial strains growing in this State are of Eastern States origin. Two types, the Dwalganup and Yarloop, strains originated in this State. The 24 strains which are known to occur are almost certainly by no means a complete list. Although the established strains are remarkably constant, variants within them occasionally do occur. The variants differ from the strain in only minor characteristics and are probably not sufficiently distinct to warrant classing as a new strain.

Most of the known Australian and European strains plus a considerable number of cross-bred types are on trial at Research Stations in this State, but it is only intended to cover in this article those which are known to occur naturally under field conditions. Four strains which have no recognised common name are not included.

Of those growing under field conditions eight may be considered commercial strains in that certified seed is either at present available on the market or should be available in the next few years. The other 12 strains which are described are those which have little economic significance and are normally found only as admixtures with the commercial types.

COMMERCIAL STRAINS

At present in this State six strains of subterranean clover are certified and recognised as commercial strains; they are as follows:—

Dwalganup—Early maturing.

Yarloop—Early maturing white seeded.

Clare, Bacchus Marsh—Early mid-season.

Mt. Barker—The standard midseason variety.

Tallarook—Late maturing.

In addition to the above, two other strains—Geraldton and "Pearsons"—may shortly reach the stage of commercial production. The Geraldton strain was isolated by Dr. A. J. Millington of the Institute of Agriculture at the University of W.A. and is being used in the breeding programme being carried out at that Institute (3). This strain flowers slightly later than Dwalganup but the seed matures much faster. For this reason, it may be useful in areas which have a shorter growing season than that required for the Dwalganup strain.

Pearsons strain has been known to occur as an admixture in Mt. Barker strain pastures for a number of years. It is particularly prominent at Greenbushes, Mt. Barker, Capel and Manjimup. Its vigorous growth habit has attracted the attention of a number of farmers. It has been harvested for sale commercially over the last few years and is becoming increasingly popular.

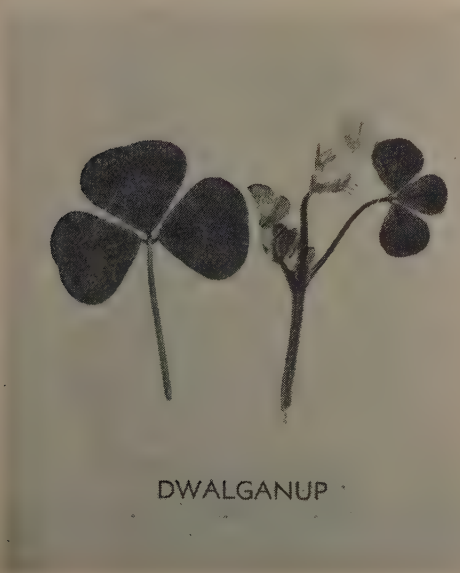


Fig. 2.

Fig. 3.

A number of other strains such as Daliak and Mulwala have been tried commercially on a limited scale but have never become popular with growers.

In order of maturity the present commercial strains are as follows:—

Dwalganup.—The most widely grown of all clovers in this State. It is the earliest flowering of all varieties, originating from Mr. P. D. Forrest's "Dwalganup" property at Boyup Brook and is thought to have been accidentally introduced with ryegrass seed about 1890. Commercial seed has been available since about 1929. It is noted for its early maturity, good winter growth and heavy seed setting. This State is a large producer of Dwalganup seed. In 1956 a total of 1,600 tons was certified (Fig. 2.)

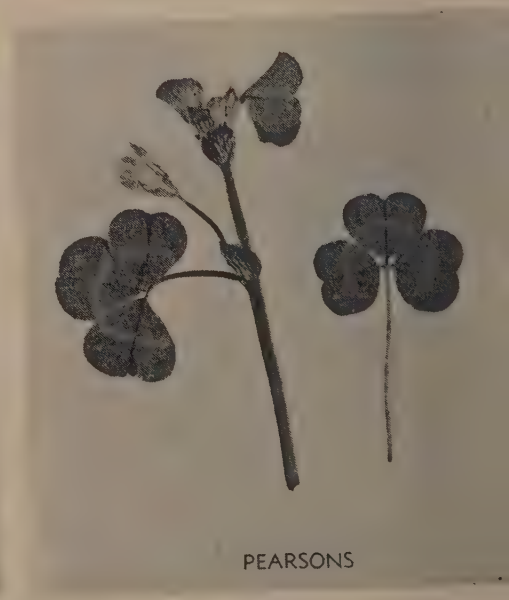
Geraldton.—The strain, as mentioned earlier, was collected by Dr. A. J. Millington at Geraldton in 1950 and has been under trial at a number of research

stations and other centres since that time. Although flowering a few days later than Dwalganup it matures a week or more earlier, and thus could be a useful clover for the drier areas. Seed stocks are at present being built up by the Institute of Agriculture and commercial certified seed should be available within a few years. (Fig. 3.)

Fig. 4.

Fig. 6.

Fig. 5.



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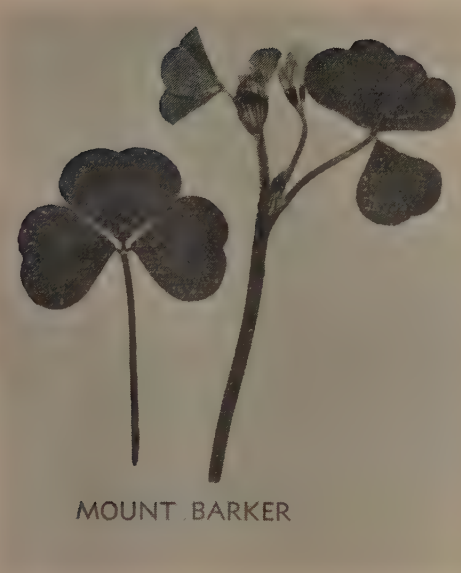

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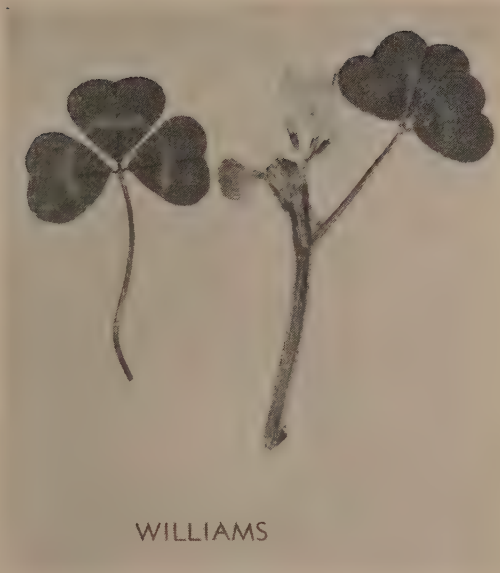
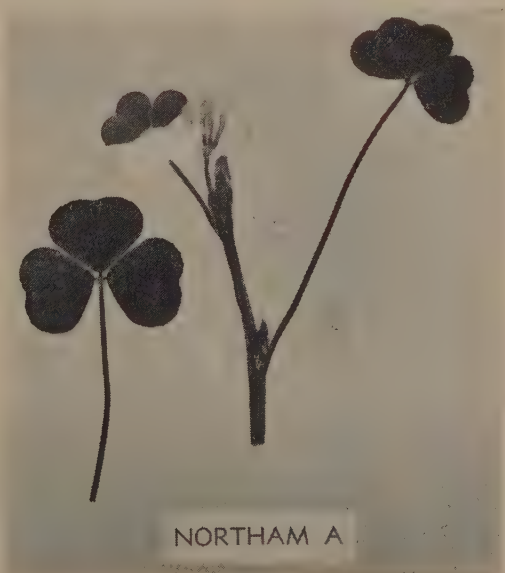


Fig. 10.

Yarloop.—This strain is also known as "White Seeded" or "Albino" clover. It was known to occur in the Yarloop district some 20 years ago. Its peculiar adaptability to wet water-logged areas made it very popular in the Harvey-Brunswick district. It makes good winter growth and is early maturing, flowering about a week later than Dwalganup. It is now widely grown over the whole of the Great Southern and South-West. Certified seed first became available in 1948, and total production has increased rapidly ever since. This is the only State which produces the seed in any quantity; last year a total of 276 tons was harvested. (Fig. 4.)

Fig. 9.



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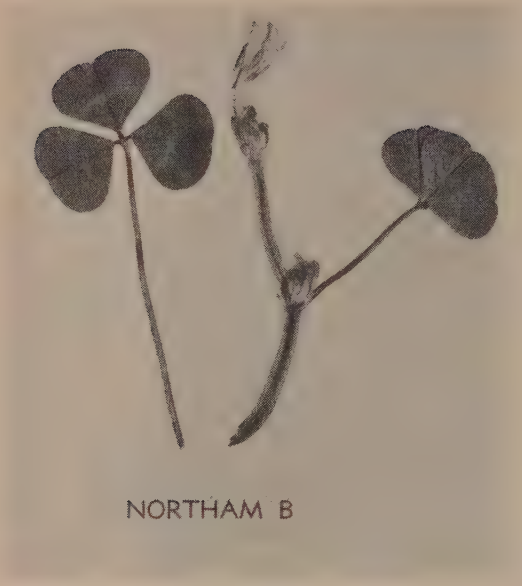

Fig. 12.

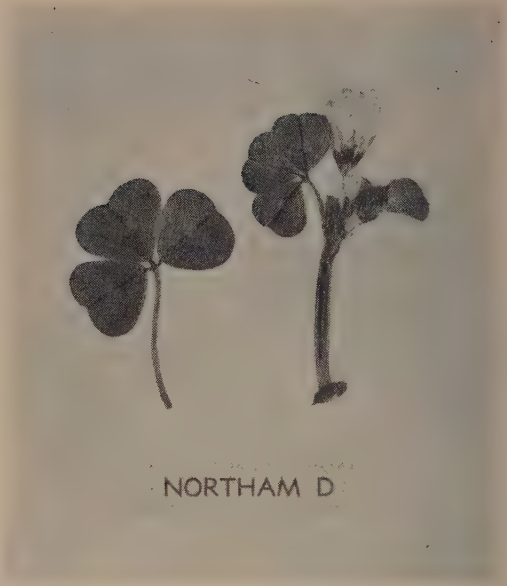

Fig. 14.

Bacchus Marsh.—As its name implies, this clover originates from the Bacchus Marsh district in Victoria. It is an early midseason type flowering normally towards the middle of September. It was first grown in the Kojonup district in 1945. Since 1950, large areas of this strain have been planted on the Land Settlement projects along the South Coast and at Esperance. The rainfall in these districts is sufficient for Bacchus Marsh, but not quite extended enough for the Mt. Barker strain. Production of certified seed in this State commenced in 1948. Total pro-

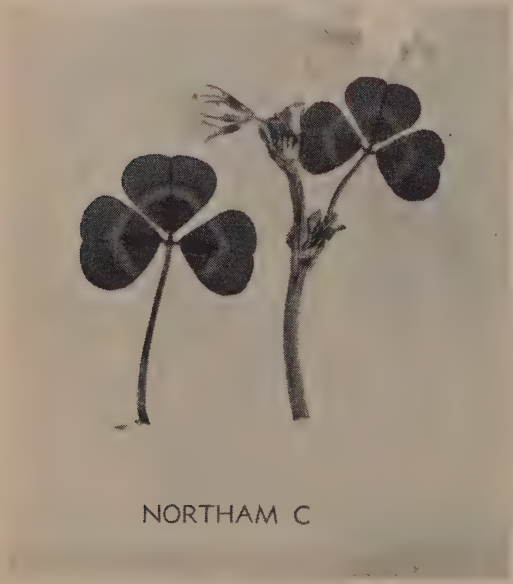

Fig. 13.

Fig. 15.

Fig. 16.

duction has never been higher than 20 tons and for this reason it has been necessary to import most of the State's requirements. (Fig. 5.)

Clare.—A South Australian strain, which has come into prominence over the last few years. It is grown commercially on a limited scale in the Eastern States. Several producers in this State have established small plots of the strain for seed production. Its maturity is approximately the same as Bacchus Marsh. It is strikingly distinctive from other strains by its brown anthocyanin-patterned upper leaf surface. It appeared to compare favourably with strains of similar maturity when under comparative trials in the Eastern States. (Fig. 6.)

Pearsons.—This clover was first noticed on Mr. L. Pearson's property at Benger in 1948 when a paddock was being examined under the certification scheme. It has also been known as "White Flowered Mid" but its more generally accepted name is "Pearsons." Since its original discovery at Benger, it has been found growing at Mt. Barker, Greenbushes, Manjimup and Capel. It has come into prominence in the last few years and a number of farmers, particularly at Greenbushes and Woogenellup, are interested in establishing it commercially. Although no detailed trials have so far been carried out it is noted for its good winter production and its general vigorous growth habit. It flowers at approximately the same time as Bacchus Marsh.

All commercial lines of seed at present available contain a varying proportion of the Mt. Barker or Dwalganup strains. A few producers are at present building up pure stands with a view to harvesting certified seed in a few years time. (Fig. 7.)

Mt. Barker.—This is the original strain from Mt. Barker in South Australia. It was introduced into this State about 1900 and has become the basic pasture plant in most of the South-West and lower Great Southern. It is also grown in the Esperance district. In 1951 over 600 tons of certified seed were produced, since then production has fallen to approximately 150 tons per annum. (Fig. 8.)

Tallarook.—This is a Victorian strain originating from the Tallarook district in that State. It is a late maturing type flowering normally about mid October. It has a very leafy growth habit and is an excellent clover for parts of the South-West in association with the Mt. Barker strain. It was introduced to this State about 1940 and is becoming increasingly popular, although as yet, is not widespread. Certified seed has been produced

Fig. 17.

Fig. 18.

on a limited scale since 1944 but the production has never exceeded 10 tons in any one year. (Fig. 9.)

OTHER MINOR STRAINS

As mentioned earlier 16 minor strains of little or no economic significance are also known to occur under natural field conditions. Some of these have been commercialised to a limited extent while others are found growing only in small patches in certain districts. A number of these minor strains have been useful in cross breeding work both here and in the Eastern States. A brief mention only of the named strains will be made. These in order of maturity are as follows:—

Dwalganup (White Seeded). — This strain is commonly found as an impurity in the normal Dwalganup pastures. It is found in all districts but is particularly prevalent in the Tambellup and Cranbrook areas.

Williams.—A strain of about the same maturity as Dwalganup from which it can be readily distinguished by its distinctly red banded calyx and indented outer leaf margin. It is found growing on a number of properties close to Williams. (Fig. 10.)

Northam Strains.—Four distinct strains of clover known respectively as Northam A, B, C and D, have been found growing at Northam. Two of these were first noticed growing at the golf links as early as 1930. They are all early maturing, being from 3 to 7 days later than Dwalganup. They are not sufficiently different from Dwalganup to warrant a detailed comparative trial. (Figs. 11-14.)

Daliak.—This strain was first noticed growing on Mr. Monger's "Daliak" property at York about 1929. It is characteristic in having no leaf markings and a deep red calyx. It is an early maturing clover flowering normally a few days later than Dwalganup. Some interest has been shown in this strain at various times and spasmodic attempts have been made to establish the plant as a pasture in various parts of the agricultural areas. As a result, although it is not a commercial clover, it is commonly found as an admixture in other strains in many districts. (Fig. 15.)

Pink-Flowered.—This strain was found growing at Muresk in 1929. It is not common and is readily distinguished by its characteristic pink petals.

Mulwala.—An Eastern States strain which at one time was produced commercially to a limited extent in New South Wales. Its maturity is approximately one week later than Dwalganup. It was tried by a number of farmers in this State about 1935 but was not a sufficient improvement on Dwalganup to warrant extensive planting. It is still found growing occasionally as an admixture in pastures, particularly at Boyup Brook. It can be distinguished from Dwalganup by its deeply indented leaflets (Fig. 16.)

Gingin.—This strain has been found growing along the roadsides near Gingin. It matures 7-10 days later than Dwalganup. It has a vigorous growth habit, and is distinguishable from other early maturing strains by its abnormally large stipules and runners and distinctly marked upper leaf surface. (Fig. 17.)

Four Leaf.—This strain is characterised by frequently having four or five leaflets on each petiole. The number of leaflets is not constant. A single plant may have three, four or five leaflets on separate petioles. This strain was found growing as an admixture in Yarloop and Mt. Barker pastures in the Harvey district a

few years ago. It is similar to Yarloop in its maturity and other characteristics. (Fig. 18.)

Wenijup.—As mentioned earlier, this clover was accidentally introduced into the Bridgetown district about 1890, and is a late maturing type. Attempts to establish it on a larger scale have been made spasmodically, it is however not as popular as the Mt. Barker and Tallarook strains. It is also known as the "Late Brunswick" strain and is found in small patches in a number of localities in the lower South-West. (Fig. 19.)

THE IDENTIFICATION OF STRAINS

Table I is adapted from a similar type of table published by Aitken and Drake in the Journal of the Victorian Royal Society (2). All the known named strains growing under field conditions in this State have been included. Naturally enough the ones which will be encountered most frequently are the commercial strains, which have been listed in heavy type. The other minor strains are shown in lighter type. The list is set out in order of maturity.

Black and white photographs of most of the strains mentioned are shown in Figs. 2-19. Naturally enough such photographs are of limited value by themselves as a means of identification, but should be useful as an aid to identification in association with the illustrative method given in Fig. 20 and Table I.

Subterranean clover shows a considerable variation in its morphological characteristics under different climatic and soil conditions. Those which may invariably be present when the plants are grown spaced apart in test rows need not necessarily show up under field conditions. Bacchus Marsh for example, always has a distinctive heavily flecked upper leaf surface when grown in test rows but under field conditions this may or may not be present.

The characteristics which are used in Table I for the identification of the strains as far as is known, do not change no matter under what conditions the plants are growing.

The meaning of the botanical terms used in Table I, i.e., calyx, stipule, etc., may be obtained by consulting Fig. 1.

A brief description of the characteristics used in the table is as follows:—

1. **Leaf.**

   (a) *Pattern of Pale Central Mark.*—Most strains have some type of marking on the upper leaf surface other than the variable brown anthocyanin flecking. In the centre of the leaf the area is a pale green colour, towards the extremities it is a whitish colour. This white marking varies in form or may be entirely absent. A diagramatic description of these markings is given in Fig. 20. Some strains, i.e. Daliak, have no leaf markings, others have either a pale central mark or a mark on the outer edge of the leaf. A few such as Dwalganup have a combination of both.

   (b) *Leaf and Petiole Hairiness.*—The hairiness of the leaf and petiole varies from none at all in the case of Clare to very hairy with Dwalganup. The degree of hairiness is divided into four categories as follows:—

   (i) No hairs.
   (ii) Few hairs.
   (iii) Hairy.
   (iv) Very hairy.

   The division between the latter three groups is purely arbitrary, and for this reason the differential degree of hairiness is not used as a definite means of distinguishing between strains. When a strain is hairless this characteristic has been used as a differential.

   (c) *Stipule Colour.*—The colour of the stipule is very variable between strains but remarkably constant within the strain. It varies from a greenish white colour with green veins to a predominantly purple red colour with red veins. For purposes of differentiation the varying stipules have been divided into four types as illustrated in Fig. 20.

Fig. 19.

2. Runner Hairiness.

The degree of hairiness on the runners has been categorised in the same manner as the petiole and leaf.

3. Flower.

(a) Corolla Colour.—The colour of the corolla or petals can be divided into three types—pure white, white with pink stripes and pink. Only one definitely pink flowered type is known, i.e., the "Pink flowered" strain and this is of minor importance. All the other strains can be placed in one of the first two groups. The Dwalganup strain frequently has a decided pink tinge in the petals, particularly when the plants are grown in rows. Under natural field conditions the colour is normally white with pink stripes.

(b) Calyx Colour.—The type of colouration on the calyx is one of the most important means of distinguishing between the various strains. The colour variation ranges from deep red over the whole calyx, e.g., Daliak to a greenish white with no red pigmentation, e.g., Bacchus Marsh. For the purposes of differentiation in the key, this characteristic has been divided into four groups, as illustrated in Fig. 20.

(c) Time of Flowering.—Subterranean clover strains can be broadly divided into "Early," "Midseason" and "Late" maturing types. Naturally enough, these groups overlap one another at times. The early group has normally commenced full flowering by the end of August. A gap of about a week follows before the first of the Midseason types, i.e., Bacchus Marsh commences to flower about mid September. The late maturing types, e.g., Tallarook, normally commence flowering about mid October.

Although the time of flowering is not a defined characteristic, it can be very useful in differentiating between strains and has therefore been included.

4. Seed Colour.

The seed colour is a distinctive characteristic only in the case of the White Seeded Dwalganup and Yarloop strains. The Mt. Barker strain has a purplish coloured seed when compared to others but this is not sufficiently distinct to be used for differentiation.

GENERAL

Naturally enough the identification of strains within a species is normally a more difficult undertaking than the identification of species within a genus. There are, however, sufficient distinctive features between the strains of subterranean clover to enable a quick determination of any flowering specimen from Table I.

To identify a specimen its characteristics as set out in Fig 20 should be tabulated and then compared with those given for each strain in Table I. In most cases the specimen will be one of the commercial strains which are listed in heavy type. Specimens of the minor strains will rarely be encountered and have been included in the table mainly for record purposes.

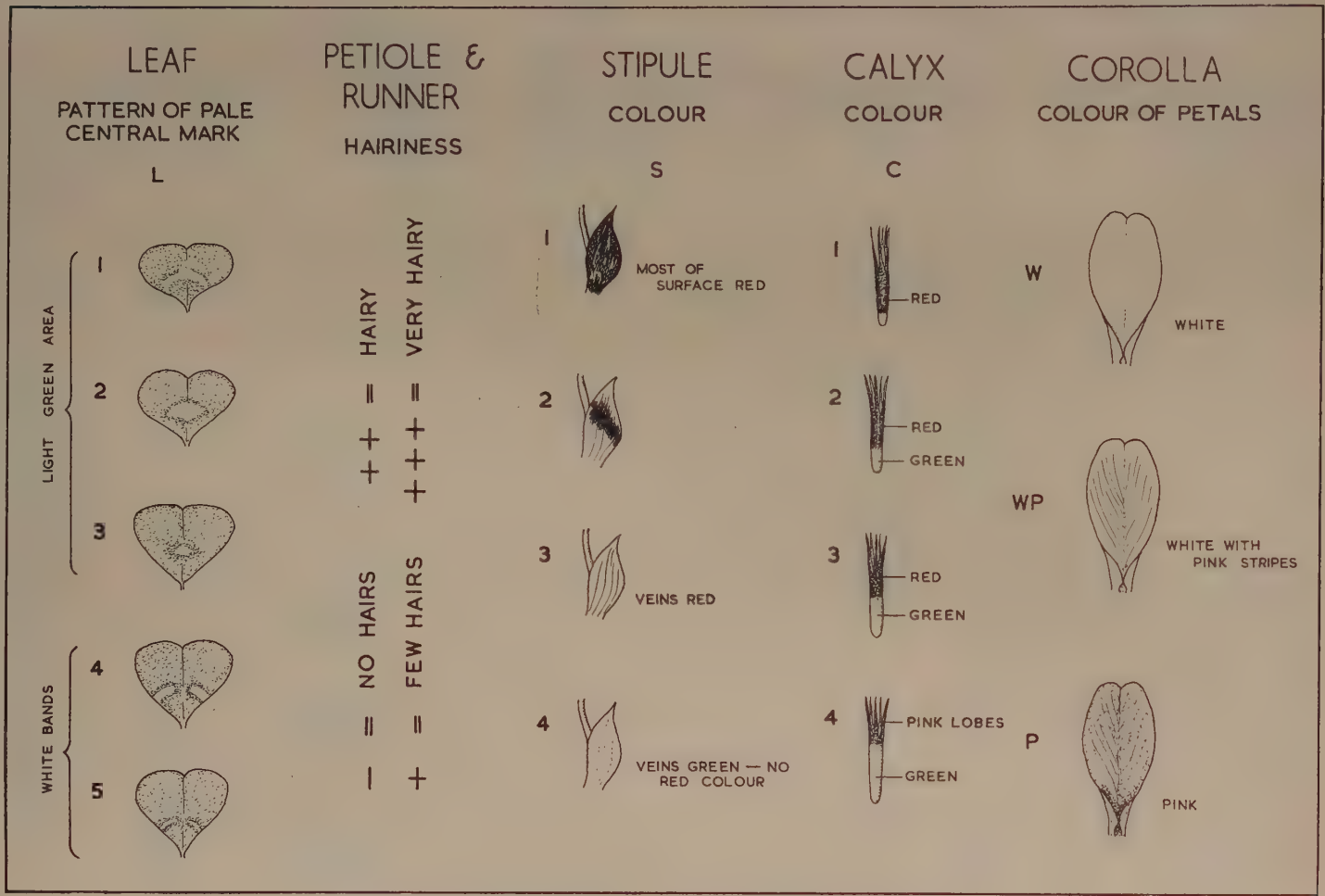

Fig. 20.—Identification chart to be used in conjunction with Table 1.

TABLE 1.

	Leaf.				Runner.	Flower.			Seed.	Other Distinctive Characteristics.
	(a) Pattern of pale central mark.	(b) Upper surface hairiness.	(c) Petiole hairiness.	(d) Stipule colour.	(a) Runner hairiness.	(a) Corolla colour.	(b) Calyx colour.	(c) Time of 1st flowering.	(a) Seed colour.	
Dwalganup	L3L5	+++	++	S3	+++	WP	C3–4	Mid-August....	Black	Leaflet not indented. corolla sometimes distinctly pinkish.
Dwalganup (White seeded)	L3L5	+++	++	S4	+++	W	green	Mid-August ...	White	No purple anthocyanin on any part of plant.
Geraldton	L1	++	++	S3	+++	WP	C1–2	Mid-August....	Black	Sometimes anthocyanin around base of leaf.
Williams	L1	+	++	S3	+++	WP	C2	Mid-August ...	Black	Leaflet distinctly indented.
Northam A	Unmarked	+++	++	S3	+++	WP	C2	Mid-August....	Black	Sometimes a thin faint pale central mark on the leaf.
Northam B	L1	++	++	S3	+++	WP	C3–4	Mid-August....	Black	Similar to Dwalganup, distinguished by mature leaf having few or no hairs below pale central mark.
Northam C	L2L4	++	++	S3	+++	WP	C2–3	Late August	Black	Anthocyanin frequently distinctive on leaf around midrib below crescent.
Northam D	L3	+++	++	S3	+++	WP	C2	Late August	Black	Anthocyanin frequently distinctive on leaf around midrib below crescent.
Daliak	Unmarked	—	+	S1	+	WP	C1	Late August	Black	
Pink Flowered ..	Unmarked	++	++	S4	++	Pink	C4	Late August	Black	Leaf small and similar to Dwalganup in general shape.
Yarloop	L5	+	—	S2	—	W	C4	Late August	White	Anthocyanin frequently along lower midrib.
Mulwala	L3L5	++	++	S3	+++	WP	C4	Late August	Black	Leaflet distinctly heart-shaped. Comparatively deep indentation in outer leaf margin.
Gingin	L2L4	++	++	S3	+++	WP	C3–4	Mid-Sept.	Black	Stipules and runners abnormally large.
Bacchus Marsh	L1	++	++	S4	++	W	green	Mid-Sept.	Black	Upper leaf surface frequently spotted with anthocyanin.
Clare	L2L4	—	—	S2	—	W	green	Mid-Sept.	Black	Anthocyanin frequently present below pale central mark on leaf.
Pearsons	L1	+	++	S2–3	—	W	green	Mid-Sept.	Black	Stipules larger than normal.
Four Leaf	L1	+	—	S2–3	—	WP	green	Mid-Sept.	Black	Distinct from other strains in having 3, 4 or 5 leaflets on each petiole. Stipules larger than normal.
Mt. Barker	L2	++	++	S2–3	++	WP	C2	Mid-Sept.	Black	
Tallarook	L3	++	+	S4	++	WP	green	Mid-October	Black	
Wenjup	Unmarked	—	+	S4	—	WP	green	Mid-October	Black	Abnormally thick runners and large stipules

ACKNOWLEDGMENTS

Acknowledgment is made to Mr. J. W. Green, Botanist, State Herbarium, for the drawing of Fig. 20 and to Dr. A. J. Millington of the Institute of Agriculture and Dr. R. C. Rossiter of the C.S.I.R.O. for providing a number of specimens.

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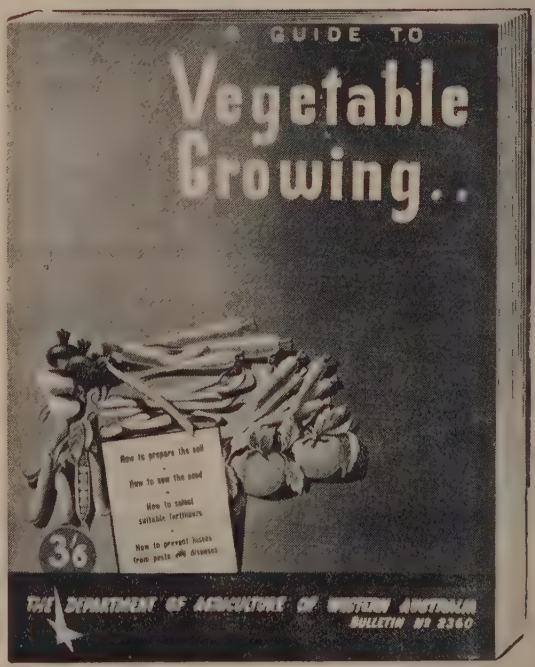

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The Tolerance of Subterranean Clover (Trifolium subterraneum L.) to Chlorinated Phenoxyacetic Derivatives

By G. R. W. MEADLY, M.Sc., Officer in Charge, Weeds and Seeds Branch, and G. A. PEARCE, B.Sc. (Agric.), Botanist

THE selective phytocidal properties of certain growth-regulating substances were confirmed when Slade, Templeman and Sexton (1945) found in 1940 that applications of 25 lb. naphthylacetic acid per acre to oats weedy with charlock (Brassica sinapis) killed the weed without causing permanent injury to the crop. Within two years of this work investigators in both England and America had recognised the strong growth-regulatory and herbicidal effects of chlorinated phenoxyacetic derivatives.

Many chemicals were screened for selective herbicidal properties and development occurred along two main lines. In America the derivatives of 2,4-dichlorophenoxyacetic acid (2,4-D) were favoured while in England, where exploratory work commenced somewhat earlier, the chemical selected for development was 2-methyl-4 chlorophenoxyacetic acid (M.C.P.A.). This was due in part at least to the greater availability in England of chloro-cresol as opposed to chloro-phenol.

In general, monocotyledons including grasses are resistant to these chemicals and broad-leaved herbaceous dicotyledons are susceptible. This is a generality with many exceptions, however, and much work in recent years has been undertaken to define the tolerance of crop and pasture species as well as the dosage required for specific weeds. In Western Australia, the main cultivated species involved are cereals and subterranean clover.

A considerable amount of research has been undertaken relative to safe levels of treatment for cereals and although some variations in results have been reported the practical position is relatively clear. Susceptible growth stages are known and it is generally recognised that oats is more likely to be affected than wheat with barley intermediate. Trials undertaken by Meadly (in press) at the Merredin Research Station involved as variables different varieties of cereals, formulations of growth regulators and rates and times of application. With the relatively low amounts of herbicides applied to weeds in cereal crops in this State, usually less than 8 oz. acid equivalent per acre, providing the growth stage of the crop is taken into consideration no significant damage to the cereal is likely.

In a country so dependent on subterranean clover as a component of pastures and a soil improver it is important that information should be available concerning its reactions to the various formulations, particularly during the season of establishment. A considerable amount of work dealing with a number of species of *Trifolium* has been published in England, America and New Zealand. Much of this pertains to perennial species such as white clover (*T. repens*) and red clover (*T. pratense*). It is not intended to review all this literature but to make reference to conclusions drawn by a few of the workers with a view to summarising the findings.

Following field trials Scragg (1953) concluded that the establishment of red clover was not seriously impaired by spraying with sodium or amine salts of M.C.P.A. at 1 lb. acid equivalent per acre, either in an undersown crop or direct reseed. The vigour of plants was reduced but not their numbers. The amine of 2,4-D had a more severe effect on red

clover than both formulations of M.C.P.A. White clover, on the whole, was not greatly reduced nor was there any marked difference between the herbicides. Amine M.C.P.A. appeared to be most and amine 2,4-D least harmful to this species. Greenhouse tests showed that alsike clover and trefoil are very susceptible to herbicides and confirmed that 2,4-D is more harmful than M.C.P.A. to red clover but no more toxic to white clover.

Pot experiments undertaken by Holly (1953) indicated that the resistance of all grasses, even in the very early seedling stages is so much greater than that of legumes that the effects on the latter must always be the primary consideration in spraying newly sown seed mixtures. Appreciable mortality of S100 white clover can be caused by doses as low as ½ lb. acid equivalent per acre of M.C.P.A. (sodium) and 2,4-D (triethanolamine) while 4 oz. of either compound can cause reduction in growth. In the case of S123 red clover growth reduction occurred with ½ lb. 2,4-D (triethanolamine) or 1 lb. of M.C.P.A. (sodium) per acre. Both grasses and clovers showed increased resistance to the two compounds with increasing age of the seedlings. As with Scragg's trials M.C.P.A. (sodium) appeared to be slightly less toxic than 2,4-D (triethanolamine) with red clover but the reverse applied with white clover. Holly could not detect differences in reaction of strains of either clover. He drew attention to the fact that commercial M.C.P.A. (sodium) formulations containing a variety of additional compounds can be more toxic than the 2,4 isomer alone when applied in low volume to S123 red clover.

Fig. 1.—Normal leaves of subterranean clover (below), compared with those affected by 2,4-D

Experiments reported by Ochiltree (1954) largely support the previous findings. He concluded that broad and late flowering red clovers are much more susceptible to damage at all stages of growth from the application of 2,4-D derivatives than from the M.C.P.A. derivatives tested at equivalent rates of application. Seedlings of white clover are more susceptible to M.C.P.A. than to 2,4-D derivatives but the difference is less marked than the reverse experience with red clover.

Clarke (1953), following work in British Columbia, summed up that generally, in the seedling year legumes are more tolerant to M.C.P.A. than to 2,4-D formulations. Several instances of damage with M.C.P.A. ester have been reported, however, and many have shown the sodium salt of M.C.P.A. to be relatively ineffective for weed control. It would appear, therefore, that the amine of M.C.P.A. will find a wide use and that amine of 2,4-D will continue to be employed, particularly where very light rates are permissable. During the last two years the amine of M.C.P.A. has gained favour in America and Canada when cereals undersown to legumes are involved. Marshall and Van Geluwe (1953) reported greater tolerance of legumes generally to the diethanolamine salt of M.C.P.A. compared with the sodium salt of M.C.P.A. and the triethanolamine salt of 2,4-D. The National Weeds Committee of Canada (Western Section) (1955) in its recommendations for 1956, states that grain crops undersown with alfalfa, red and alsike clover can be treated to kill susceptible weeds with M.C.P.A. amine at 2-4 oz. acid equivalent per acre or with the sodium salt at 3-6 oz. per acre.

Since the advent of pasture spraying for weed control in New Zealand, detailed work has been carried out on the tolerance of clover species to herbicides including the hormone-like chemicals. Fitzgerald (1953) reported that preparations

Fig. 2.—Showing the equipment used for spraying in the clover tolerance trials at Narrogin (July 20, 1955)

of M.C.P.A. appeared to be less severe on clovers than those of 2,4-D and that at the seedling stage subterranean clover was more tolerant than white clover with red clover intermediate. All species became more tolerant with increasing age.

Following further work Lynch (1954) supported Fitzgerald's observations and indicated increasing severity in the order of metallic salts, amine salts and esters. Unfortunately the water-based polyethylene glycol esters and esters of M.C.P.A. caused as much damage as the more frequently used ethyl, butyl and butoxyethanol esters. White clover alone seemed more susceptible to M.C.P.A in the young stages but once past, say six months growth, white clover falls into line with the other clover species and M.C.P.A. has less effect on it than 2,4-D. New Zealand trials and experience are reported fully by Maclean (1955) and Maclean, Matthews and Fitzgerald (1955), their conclusions being similar to those of Fitzgerald and Lynch.

Following trials at Walpeup, Longerenong and Werribee, Hore (1954) reported on the tolerance of cereals and barrel medic (*Medicago tribuloides*) to various formulations. The population of barrel medic sown with a wheat crop was significantly reduced by the application per acre of 2 oz. acid equivalent ester 2,4-D, 4 oz. sodium M.C.P.A. or 4 oz. amine 2,4-D. With trials under pasture conditions Johnston, Russell, Preston and Done (1954) found that the reaction of subterranean clover varied according to the time of spraying, the formulation used and the strain.

Applications of up to 16 oz. acid equivalent per acre of the sodium salt and amine of M.C.P.A. did not noticeably affect clover density, leaf size or flowering at any rate or at any time of spraying. All formulations of 2,4-D at all rates including 4 oz. acid equivalent per acre affected subterranean clover. It was considered that only at the 1 lb. rates reduction in the number of clover plants occurred.

Meadly and Pearce (1955) noted while undertaking some exploratory work in 1952 on a pasture dominated by the Dwalganup strain of subterranean clover that plants, except at the small seedling stage, were not readily killed by growth-regulating herbicides. Many plants persisted following the application of 2 lb. acid equivalent per acre of sodium M.C.P.A. and 1½ lb. amine 2,4-D. It was apparent, however, that even light applications as low as 4 oz. acid equivalent per acre retarded the date of flowering. At Toodyay in 1954 a crop of wheat undersown with Dwalganup subterranean clover was sprayed at rates of 4, 8, 12, 16, 24 and 32 oz. acid equivalent per acre of sodium M.C.P.A. amine 2,4-D and ethyl ester 2,4-D. With M.C.P.A. the yield of seed per subterranean clover plant was significantly depressed for all treatments above the 16 oz. level. In the case of amine 2,4-D the depression occurred with all treatments above the

Fig. 3.—Growth stage of plants at Narrogin when sprayed on July 27. The coin is a florin

4 oz. level while with the ester 2,4-D all treatments caused a significant reduction in seed yield.

FURTHER TRIALS

A practice often followed for the establishment of subterranean clover, particularly the Dwalganup strain, is to sow along with a cereal. Frequently, weed growth in the crop warrants spraying but any appreciable effect on seed formation of the clover in the first year can affect seriously the rate of establishment. Unlike when dealing with old clover land few, if any, dormant seeds from the initial sowing are present in the soil at the commencement of the second season when regeneration is dependent upon seed formed in the season of sowing. Most overseas investigations have dealt with white and red clovers and trials in which subterranean clover has been included have pertained practically entirely to pasture conditions. When subterranean clover has received attention, the main considerations have been the lethal dosage at different growth stages and also the effect on yield. Although these aspects are important to Western Australian agriculture, the main question to be answered is the reaction to various formulations of clover sown with a cereal crop. Experience has shown that weeds are usually more susceptible to growth-regulating herbicides when growing with cereals than under pasture conditions. It is reasonable to assume that subterranean clover would react in a similar manner. When the clover plants are beyond the young seedling stage the rates usually applied are unlikely to cause a high proportion of mortality but the effect on floral development and time of flowering can be a major factor influencing seed setting and consequently re-establishment the following season. In the lower rainfall districts the short growing season is barely adequate for the early Dwalganup strain and any delay in flowering must be viewed with concern.

Tentative recommendations were possible following the Toodyay trial already referred to, but bearing in mind the importance of any decision regarding spraying, it was decided to extend the scope of the trials and undertake them at four different centres— Geraldton, Bolgart, Toodyay and Narrogin. By widely spacing the trial centres and undertaking the work in successive seasons it was considered that most of the difficult variables associated with such research could be eliminated. Owing to rain falling shortly after application of the chemicals it was necessary to discard the results obtained from Bolgart.

The treatments and layout were the same at each centre. The chemicals applied were 4, 8, 12, 16, 24 and 32 oz. acid equivalent per acre of sodium M.C.P.A. triethanolamine 2,4-D and ethyl ester 2,4-D. For convenience these will be referred to as M.C.P.A., amine and ester and

references to ounces will imply acid equivalent per acre. No check was made of the 2-4 isomer content of the M.C.P.A. Each plot was 12ft. wide and three chains long and each treatment was replicated three times. Spraying was carried out with a 12ft. boom, seven gallons of solution per acre being applied. The centre 6ft. of each plot was used for assessing results. At each site the chemical was applied at the growth stage of weeds and crop considered most advantageous for the control of the weeds, at the same time presenting minimum risk of crop damage. The wheat was six to eight inches high and stooling but there was some difference in the size of the clover plants at the different centres. By sowing the clover at 8 lb. per acre an adequate emergence was obtained for assessment of results.

Observations and recordings were made with a view to defining effects on the growth and population of the clover plants, number and periodicity of flowers, seed formation, size of seed and germination. The most satisfactory way of obtaining and recording this information presented some difficulties, particularly with reference to flowering periods and numbers of flowers produced. Establishment counts of clover seedlings were made at the time of spraying, 3 x 4 square links being used. With three replications, plants on 36 square links were recorded for each treatment. Survival counts were made later, on the same quadrats which were also used subsequently for the seed production estimations. With a strain having the spreading habit of Dwalganup, burrs arising from plants within the quadrats were formed beyond their confines but at the same time intrusions from plants outside also occurred. It was found impracticable to trace all burrs arising from the recorded plants and in view of the reciprocal interchange of runners, all burrs within the quadrats were harvested. Following separation of the burrs from the soil, the seeds were removed by means of a small motor driven thresher, specially constructed for handling experimental quantities.

The same quadrats were also used for the flower counts. The first was made as soon as flowers appeared and the counts were repeated at approximately weekly intervals until flowering was virtually completed. There was no way of ensuring that the same flower heads were not recorded at successive counts but, as the

Table 1—TOODYAY.

Treatments.	Initial Plant Count.	Final Plant Count.	Total Flower Count.	Total Seed Count.	Average Seeds per Initial Plant.	Total Seed Weight gms.	Germination per per cent.
4 ozs. Sodium MCPA	153	107	505	5,917	36·9	63·52	97
8 „ „ „	153	96	551	6,417	41·9	60·83	92
12 „ „ „	153	111	363	4,625	30·2	56·90	92
16 „ „ „	143	93	313	4,385	30·7	56·74	92
24 „ „ „	149	124	292	4,095	27·5	54·25	94
32 „ „ „	156	116	252	2,664	17·1	43·16	92
4 ozs. Amine 2, 4-D	149	112	412	4,513	30·3	50·74	90
8 „ „ „	126	120	318	3,439	27·3	60·01	93
12 „ „ „	134	98	255	3,353	25·0	60·32	92
16 „ „ „	144	121	313	3,707	25·7	55·44	94
24 „ „ „	139	106	219	2,221	16·0	40·48	90
32 „ „ „	151	119	150	1,098	7·4	43·48	89
4 ozs. Ester 2, 4-D	151	115	395	4,099	27·1	66·82	91
8 „ „ „	133	105	340	3,462	26·0	49·44	90
12 „ „ „	136	117	341	2,838	20·9	55·61	92
16 „ „ „	135	110	214	2,469	14·9	48·74	91
24 „ „ „	162	132	254	2,039	12·6	45·82	93
32 „ „ „	150	114	223	1,425	11·9	43·00	89
CONTROL 1	144	106	927	3,986	27·7	63·81	91
„ 2	138	98	905	5,343	38·7	54·86	93
„ 3	157	101	927	4,586	29·2	55·85	96

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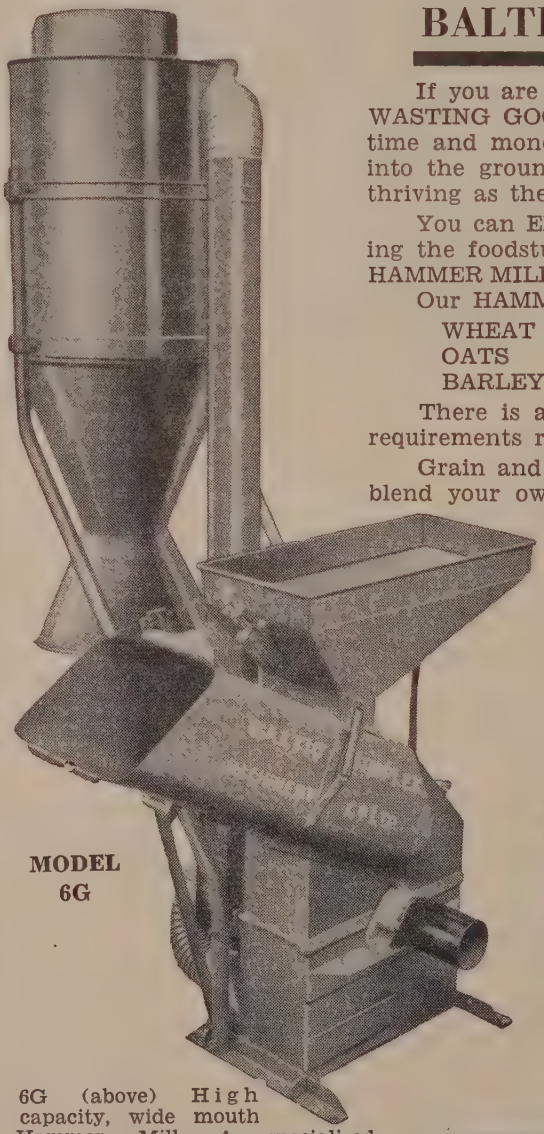

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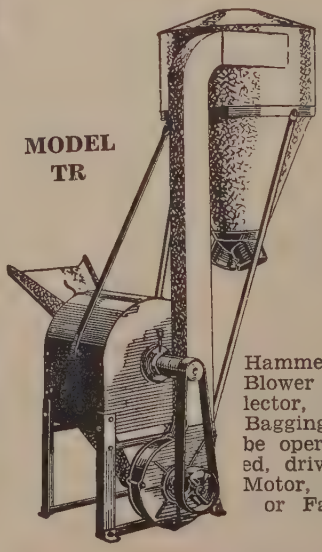

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Table 2—TOODYAY.

Treatments.	Plants (36 sq. links).	Flower Heads.							Total effective flower heads.	Effective flower heads per plant.
	2-9-55.	2-9-55.	12-9-55.	22-9-55.	29-9-55.	10-10-55.	21-10-55.	3-11-55.		
4 ozs. Sodium MCPA	153	93	19	28	**195**	164	86	13	505	3·3
8 „ „ „	153	79	18	24	158	**233**	86	22	541	3·5
12 „ „ „	153	86	2	3	67	**169**	89	33	363	2·4
16 „ „ „	143	86	....	....	34	**166**	94	19	313	2·2
24 „ „ „	149	90	....	....	11	**132**	109	40	292	2·0
32 „ „ „	156	95	....	....	1	**83**	**118**	50	252	1·6
4 ozs. Amine 2, 4-D	149	84	....	....	96	**175**	101	40	412	2·8
8 „ „ „	126	80	....	....	28	**154**	101	35	318	2·5
12 „ „ „	134	80	....	....	3	90	**111**	51	255	1·9
16 „ „ „	144	97	....	....	8	142	**139**	32	321	2·2
24 „ „ „	139	79	....	....	....	68	**97**	54	219	1·6
32 „ „ „	151	89	....	....	....	15	54	**81**	150	1·0
4 ozs. Ester 2, 4-D	151	101	....	....	28	**207**	109	51	395	2·6
8 „ „ „	133	81	....	....	....	**151**	109	80	340	2·5
12 „ „ „	136	91	....	....	....	113	**154**	74	341	2·5
16 „ „ „	135	71	....	....	....	73	**94**	47	214	1·6
24 „ „ „	162	106	....	....	....	44	**143**	67	254	1·5
32 „ „ „	150	93	....	....	....	44	**95**	84	223	1·5
CONTROL 1	144	93	217	**226**	175	95	78	43	927	6·4
„ 2	138	95	181	**199**	190	118	81	41	905	6·5
„ 3	157	105	196	**225**	180	107	88	26	927	5·9

same procedure was followed with all treatments, the figures obtained enabled comparisons to be made between flower population and time of flowering for the various treatments.

Figures relative to each centre have been tabulated and are given as totals for the 36 square links of each treatment utilised. The method found most convenient for presenting the effect of treatment on seed yield was to graph ounces acid equivalent per acre of each chemical against the average of log $(x + 1)$ with x being the number of seeds per four square links.

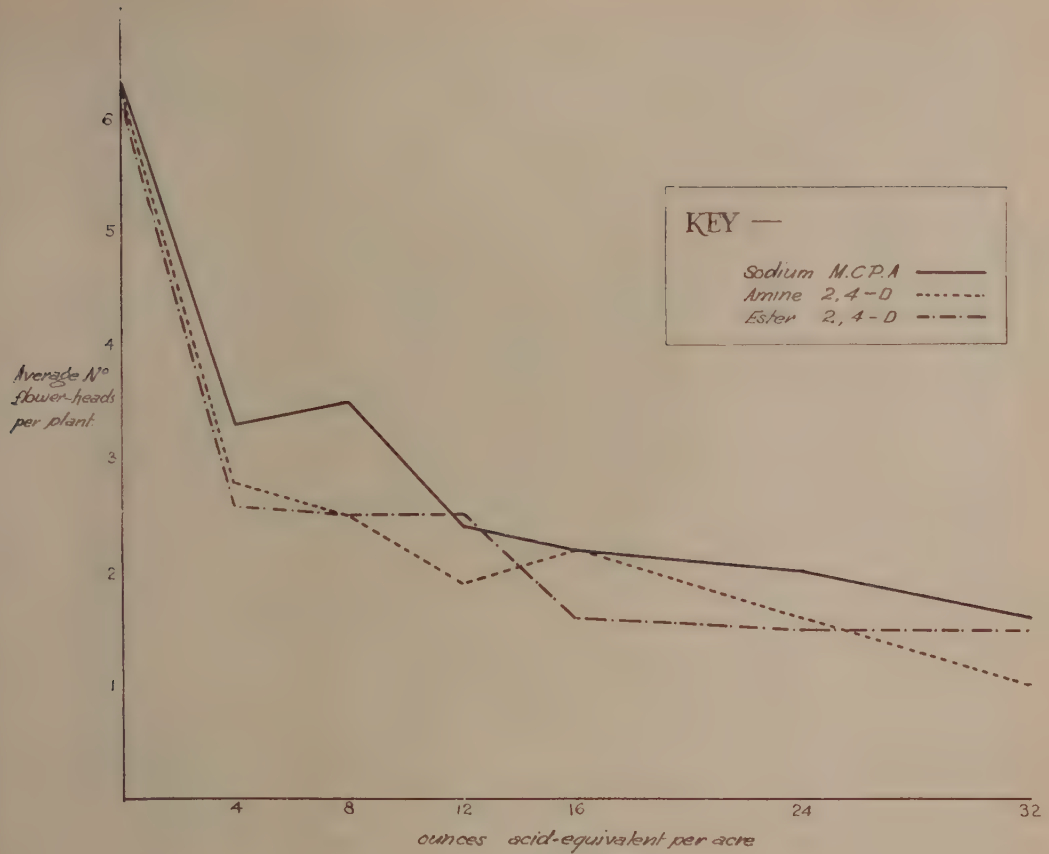
TOODYAY

The site consisted of a loamy sand previously growing York Gum (*Eucalyptus foecunda* var. *loxophloeba*), Wandoo (*E. redunca* var. *elata)* and Jam (*Acacia acuminata*). A previous cereal crop was grown in 1954 immediately following clearing.

Spraying was carried out at Toodyay on September 2, a little later than planned due to boggy conditions. The clover plants were more advanced than at other centres being up to six inches across, and flowering had commenced. Flowering was depressed and retarded by all treatments as shown by Table 2 which records the numbers of flowers present on the various plots at approximately weekly intervals from the date the chemicals were applied. Besides the reduction in total number of flowers compared with the controls the date of maximum flowering shown in heavy type was delayed to varying extents. Four ounces acid equivalent of M.C.P.A. retarded the date by seven days; 8, 12, 16 and 24 oz. by 18 days and 32 oz. by 29 days. The effects of the amine and ester of 2,4-D were more severe, the largest recorded delay in maximum rate of flowering being 42 days.

It is likely that the small number of flowers recorded for the 4, 8 and 12 oz. M.C.P.A. plots on September 12 and 22, were due to new flowers appearing rather than to survival of any of those present at the time of spraying. Based on this assumption, spraying arrested the development of all flowers present and in the case of most treatments delayed the appearance of further flowers for a lengthy period.

Graph 1 shows that the average of 6.3 flower heads per plant on the control plots was reduced at all levels of the three formulations used. The tendency was for



— GRAPH 1 —

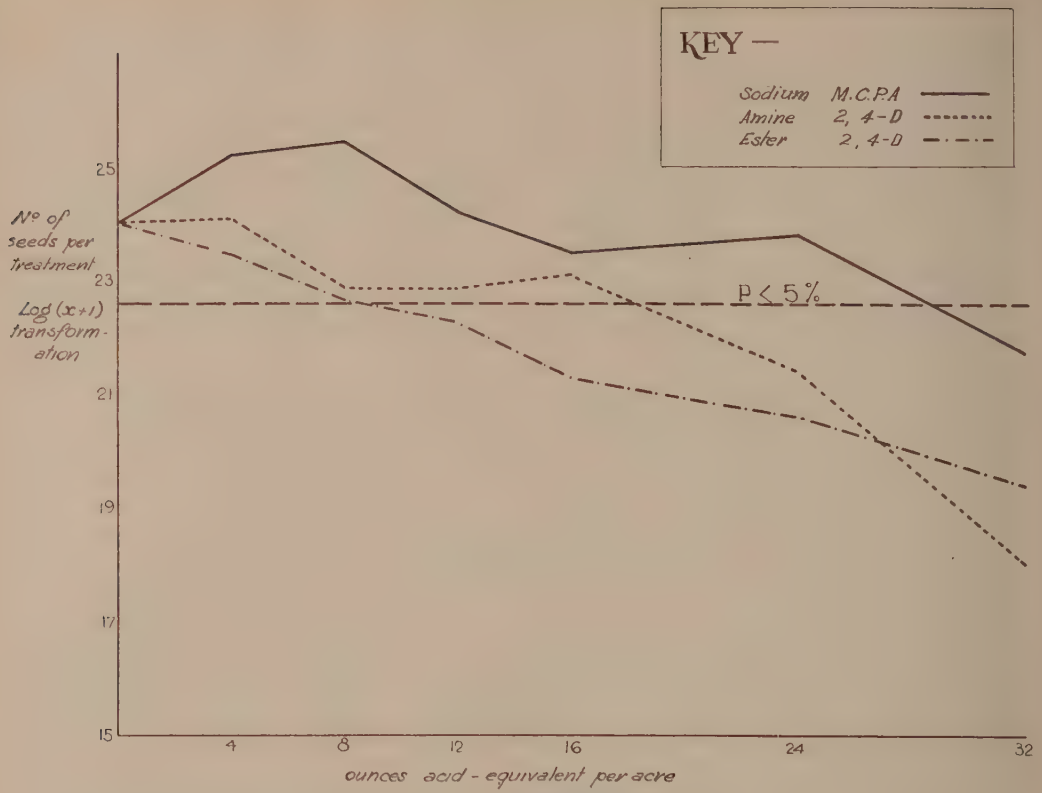
Showing the effects of three formulations at different levels on the average number of flower-heads per plant (Toodyay)

greater reduction with higher rates of application but the three formulations followed a similar pattern.

The initial and final plant counts showed that there was no greater reduction with any of the treatments than with the controls. A proportion of seedling wastage can always be expected as indicated by Meadly (1946). The number of seeds produced was reduced significantly at the higher levels of all treatments as shown by Graph II.

As the plant numbers remained relatively uniform the average number of seeds per plant showed a corresponding reduction. At the $P < 5$ per cent. level a significant reduction in seed numbers occurred above 8 oz. acid equivalent ester 2,4-D, 16 oz. amine 2,4-D and 24 oz. sodium M.C.P.A. Viability of the seed was not affected by any treatment, the germination figures listed in Table I being uniform and high.

The effect on seed formation must be interpreted in relation to the season and unfortunately, from the viewpoint of this experiment, the long growing season of 1955 was inopportune. Based on Prescott's formula of effective rainfall being equivalent to rainfall $0.54 \times (\text{evaporation})^{0.7}$, the average date of closure of the growing season at Toodyay is October 9, and in 1955 the season was extended by four weeks. From Table 2 it can be seen that maximum flowering of untreated plants occurred on September 22, M.C.P.A. treat-



— GRAPH 11 —

Seed produced in relation to chemical applied (Toodyay)

ments up to 24 oz. acid equivalent per acre and ester and amine of 2,4-D up to 8 oz. had reached this stage by October 10. Other treatments were appreciably later. In 1955, October 10 was still four weeks in advance of the estimated conclusion of the growing season. There is no doubt that the effects of treatments would have been much more severe in an "average" growing season having a closing date of October 9. With nine of the treatments the flowering peak was reached after October 10 and in 11 cases more flowers were recorded after than before that date. This contention is supported by the earlier work of Meadly and Pearce (1955) at Toodyay in which the yields of subterranean clover seed were significantly depressed by sodium M.C.P.A. treatments above the 16 oz. acid equivalent per acre level, by all treatments of amine 2,4-D above 4 oz. and by all ester 2,4-D treatments including 4 oz. These trials were undertaken in 1954 when the effective growing season closed on September 30.

An increase in seed production with 4 oz. and 8 oz. sodium M.C.P.A. would at first appear to be an anomaly. There was a similar trend at Narrogin, however, and the slight delay in flowering could have resulted in more favourable conditions for seed formation, temperature and light period being possible factors. Again, the stimulation of crops by low rates of growth regulators has been postulated and this possibility cannot be excluded.

NARROGIN

The area used for the trial comprised a gritty sand overlying clay and, during the winter, water remained on the surface for

lengthy periods. The land, which carried mainly sheoak (*Casuarina Huegeliana*) had been cleared for some time but had not previously been sown to clover. Spraying was carried out on July 27, when the clover plants were two to three inches across and mainly at the four trifoliate leaf stage.

Table 3—NARROGIN.

Treatments.	Initial plant counts.	Final plant counts.	Total flower count.	Total seed count.	Average seeds per initial plant.	Germination per cent.
4 ozs. Sodium MCPA	232	232	1,096	18,300	78·9	94
8 „ „ „	266	259	1,318	14,440	55·5	97
12 „ „ „	224	213	899	12,935	57·7	97
16 „ „ „	193	193	669	12,097	62·7	96
24 „ „ „	209	209	771	10,886	52·1	94
32 „ „ „	259	241	478	8,890	34·3	93
4 ozs. Amine 2, 4-D	239	239	1,090	10,582	44·3	96
8 „ „ „	213	212	929	10,503	49·3	92
12 „ „ „	235	233	469	9,386	39·9	93
16 „ „ „	182	179	454	9,762	53·6	92
24 „ „ „	267	247	431	8,432	31·6	92
32 „ „ „	213	151	224	6,587	30·9	92
4ozs. Ester 2, 4-D	250	250	678	10,128	40·5	93
8 „ „ „	217	205	224	8,670	39·9	90
12 „ „ „	204	195	226	7,744	24·0	96
16 „ „ „	251	147	151	4,756	18·9	91
24 „ „ „	268	152	131	3,979	14·9	93
32 „ „ „	234	64	51	1,190	5·1	93
CONTROL 1	182	182	1,044	10,953	60·2	97
„ 2	205	205	1,088	11,350	55·4	95
„ 3	264	264	978	15,770	59·7	99

Table 4—NARROGIN.

Treatments.	Plants.	Flower heads.								Total effective flower heads.	Effective flower heads per plant.
	20-7-55.	2-9-55.	3-9-55.	16-9-55.	23-9-55.	30-9-55.	7-10-55.	14-10-55.	20-10-55.		
4 ozs. Sodium MCPA	232	66	140	195	**304**	170	169	38	14	1,096	4·7
8 „ „ „	266	111	209	348	**376**	129	126	16	3	1,318	3·9
12 „ „ „	224	21	83	186	**306**	125	142	29	7	899	4·0
16 „ „ „	193	12	49	164	**214**	97	117	11	5	669	3·5
24 „ „ „	209	19	58	166	**196**	131	163	19	19	771	1·6
32 „ „ „	259	3	18	125	**147**	54	114	15	2	478	1·8
4 ozs. Amine 2, 4-D	239	50	169	251	**323**	126	154	14	3	1,090	4·5
8 „ „ „	213	84	163	229	**238**	98	88	23	6	929	4·4
12 „ „ „	235	21	50	71	**165**	47	96	15	4	469	2·0
16 „ „ „	182	10	72	75	**152**	44	84	11	6	454	2·5
24 „ „ „	267	....	28	56	111	76	**121**	25	14	431	1·6
32 „ „ „	213	....	18	28	47	29	**79**	17	6	224	1·0
4 ozs. Ester 2, 4-D	250	14	98	162	**209**	51	132	9	3	678	2·7
8 „ „ „	217	....	10	24	56	25	**91**	10	8	224	1·0
12 „ „ „	204	....	5	17	45	28	**104**	21	6	226	1·1
16 „ „ „	251	....	....	5	12	25	**78**	22	9	151	0·6
24 „ „ „	268	....	....	3	4	10	**90**	17	7	131	0·5
32 „ „ „	234	....	....	2	1	5	**38**	2	3	51	0·2
CONTROL 1	182	72	154	264	**297**	115	114	19	4	1,039	5·7
„ 2	205	67	171	283	**310**	104	118	11	1	1,065	5·2
„ 3	264	74	165	252	**319**	73	108	14	1	1,006	3·8

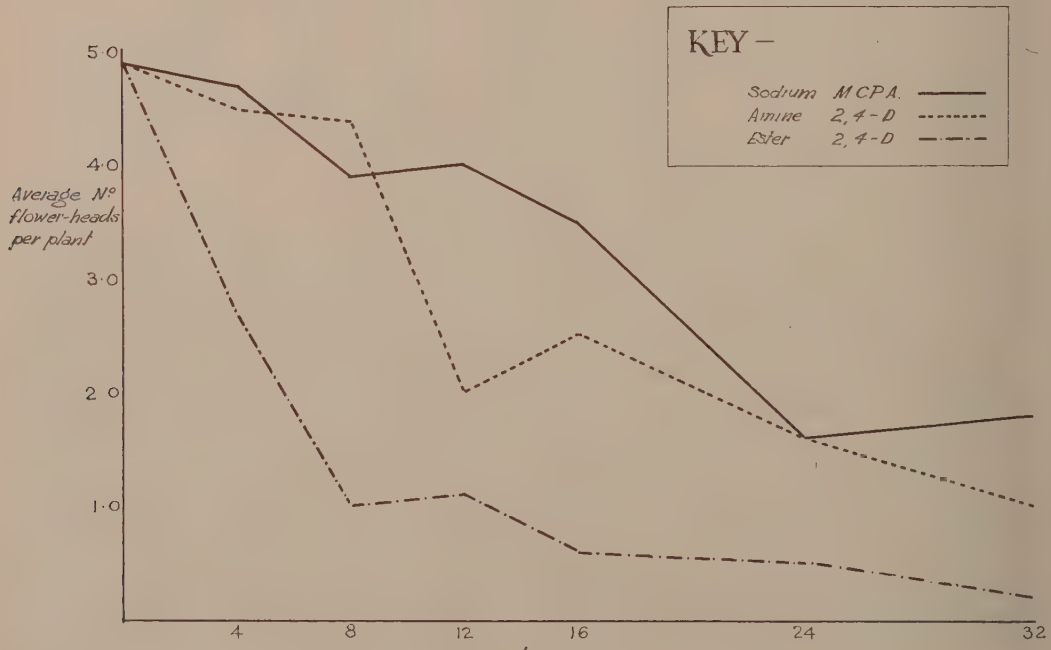
Flowering commenced on September 2, and flower counts were then continued at weekly intervals until October 20. Table 4 shows that the controls along with all sodium M.C.P.A. treatments reached the flowering peak on September 23. This also applied with 4, 8, 12 and 16 oz. amine 2,4-D and 4 oz. ester 2,4-D. The corresponding date for the two highest amine treatments was retarded by 14 days to October 7, which also applied with all ester treatments above the 4 oz. level.

Graph III shows a steep reduction in flower heads per plant with all ester treatments. There was no decided decrease with 8 oz. amine 2,4-D or 16 oz. sodium M.C.P.A. but above these levels there was an obvious reduction in the number of flower heads per plant. This arbitrary figure was based on the intial plant counts and therefore plant mortality accentuated the reduction.

The initial and final plant counts (Table 3) show no wastage in the controls and also a number of the treatments. This is unusual and reflects the very favourable conditions including freedom from weeds and absence of insect pests. The only appreciable reduction in plant members occurred with 32 oz. amine 2,4-D and 16, 24 and 32 oz. ester 2,4-D.

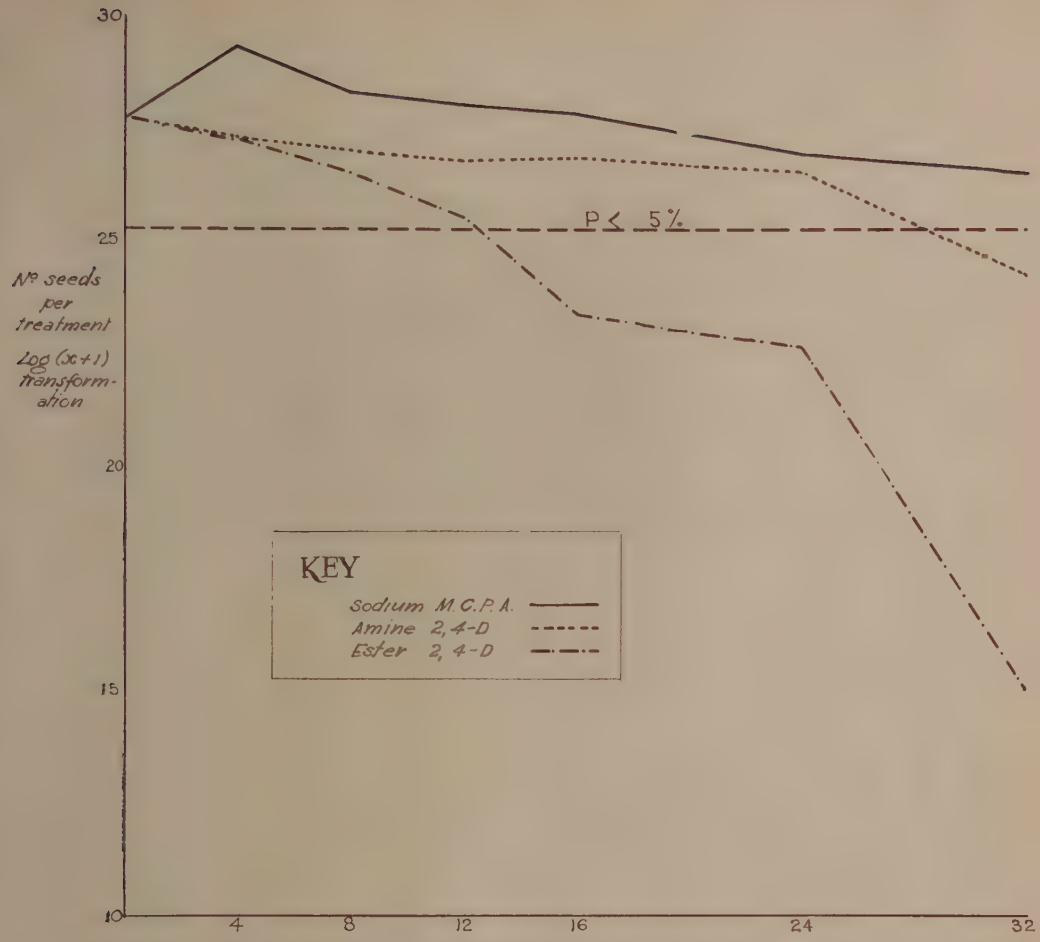
The effect of the treatments on seed setting is shown in Graph IV. At $P < 5$ per cent. sodium M.C.P.A. caused no significant reduction which was also the case with amine 2,4-D except for the highest rate—32 oz. acid equivalent per acre. With ester 2,4-D, however, all treatments above 12 oz. gave significant reductions and 12 oz. level itself was marginal.

As already mentioned, the interesting trend of increased seed production with the lower levels of M.C.P.A. experienced at Toodyay was repeated at Narrogin. The



— GRAPH III —

Showing the effects of three formulations at different levels on the average number of flower-heads per plant (Narrogin)



— GRAPH IV —

Seed produced in relation to chemical applied (Narrogin)

germination of the seed was not affected by any treatment and was uniformly high as shown in Table 3.

The growing season at Narrogin was estimated to have been extended by nine days in 1955. It was apparent, throughout the season, however, that a relatively impervious layer near the surface, retained the moisture and the experimental site was boggy for extended periods. This would have created a longer growing season than that estimated climatically.

GERALDTON

The experimental area 20 miles north-east of Geraldton was comprised of a sandy soil previously growing low sand plain scrub. The land was newly cleared. The plots were sprayed on July 6, when the somewhat unthrifty clover plants were about two inches across with three to four trifoliate leaves.

Plant wastage occurred on all plots including the controls but was most manifest in the case of the higher levels, particularly of amine and ester 2,4-D.

Table 5—GERALDTON.

Treatments.	Initial plant count.	Final plant count.	Total flower count.	Total seed count.	Average seeds per initial plant.	Total seed weight gms.	Germination per cent.
4 ozs. Sodium MCPA	144	84	645	1,257	8·7	8·74	97
8 „ „ „	151	100	625	1,237	8·2	8·15	97
12 „ „ „	116	69	455	809	7·0	5·44	97
16 „ „ „	151	75	373	438	2·9	2·51	90
24 „ „ „	210	55	267	220	1·0	1·33	93
32 „ „ „	153	43	107	81	0·5	0·45	83
4 ozs. Amine 2, 4-D	164	108	550	1,214	7·4	8·43	97
8 „ „ „	187	128	675	1,298	6·9	9·38	93
12 „ „ „	139	76	247	307	2·2	1·96	85
16 „ „ „	164	76	269	234	1·4	1·45	92
24 „ „ „	152	46	120	55	0·4	0·37	93
32 „ „ „	135	21	31	25	0·2	0·14	90
4 ozs. Ester 2, 4-D	144	107	401	1,044	7·2	6·13	89
8 „ „ „	146	88	451	650	4·5	4·32	98
12 „ „ „	175	81	220	265	1·5	1·40	85
16 „ „ „	124	41	98	49	0·4	0·45	97
24 „ „ „	127	35	55	31	0·2	0·17	75
32 „ „ „	157	22	15	10	0·1	0·06	86
CONTROL 1	158	117	771	2,330	14·7	12·63	98
„ 2	133	82	851	1,220	9·1	8·28	95
„ 3	119	103	860	1,818	15·3	16·81	97

Table 6—GERALDTON.

Treatments.	Plants.	Flower heads.			Total flower heads.	Average flower heads on plant.
		25–8–55.	9–9–55.	29–9–55.		
4 ozs. Sodium MCPA	144	67	552	26	645	4·5
8 „ „ „	151	46	555	24	625	4·1
12 „ „ „	116	34	400	21	455	3·9
16 „ „ „	151	10	357	6	373	2·3
24 „ „ „	210	5	242	20	267	1·3
32 „ „ „	153	1	98	8	107	0·7
4 ozs. Amine 2, 4-D	164	24	491	35	550	3·4
8 „ „ „	187	41	607	27	675	3·6
12 „ „ „	139	6	225	16	247	1·8
16 „ „ „	164	15	247	7	269	1·6
24 „ „ „	152	3	106	11	120	0·8
32 „ „ „	135	....	31	....	31	0·2
4 ozs. Ester 2, 4-D	144	28	355	18	401	2·8
8 „ „ „	146	7	406	38	451	3·0
12 „ „ „	175	4	267	49	320	1·8
16 „ „ „	124	....	85	13	98	0·8
24 „ „ „	127	....	50	5	55	0·4
32 „ „ „	157	....	15	....	15	0·1
CONTROL 1	158	74	736	50	860	5·4
„ 2	133	92	719	40	851	6·4
„ 3	119	64	660	47	771	6·5

It was only possible to make three flower counts between commencement of flowering on August 25, and virtual completion on September 29. These figures did not permit conclusions regarding effect of treatment on date of maximum flowering but the average number of flower heads per plant was reduced considerably by the higher rates, particularly of ester 2,4-D. The trend is shown in Graph V.

Graph VI shows the marked effect of treatments on seed setting. All rates of ester, including 4 oz. acid equivalent per acre caused a significant reduction in seed yield at $P < 5$ per cent. Rates of M.C.P.A. and amine in excess of 8 oz. also caused reductions with a tendency for M.C.P.A. to be less severe. Even below this level there was a definite trend with both formulations. The germination figures were more variable than those from the other centres but were all relatively high and did not indicate any relationship to treatment.

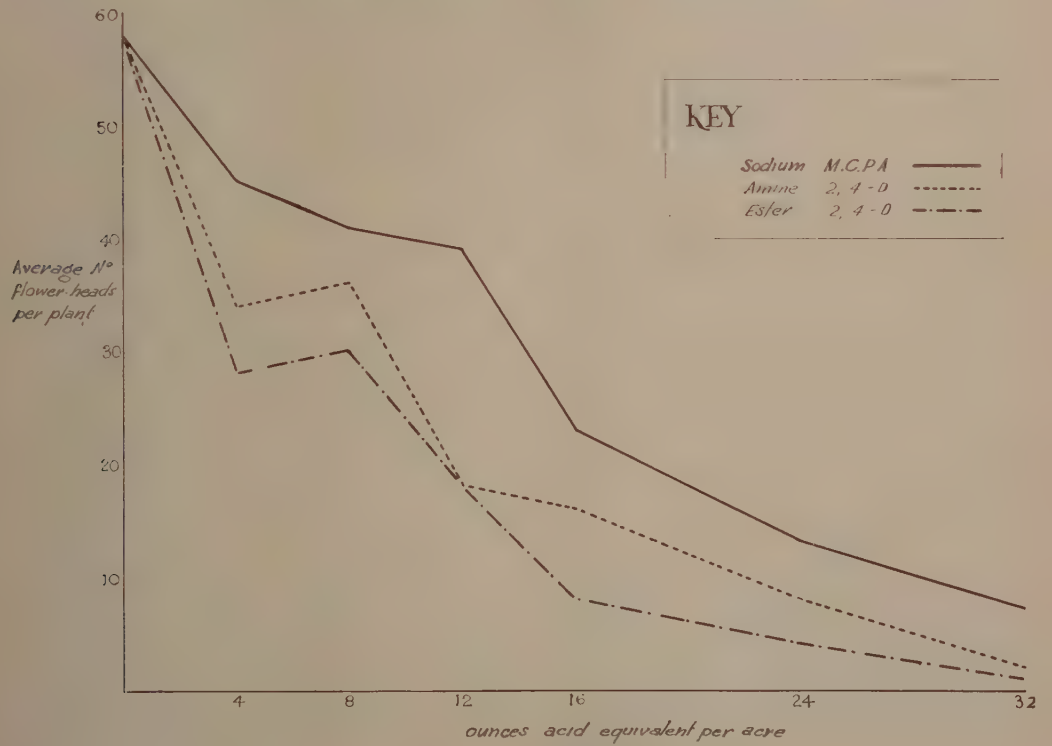
Based on Prescott's formula, the growing period was three weeks longer than in an average season. Presumably the low vigour of the plants precluded them from being benefited to any extent by the favourable season and also made them more vulnerable to the growth regulators. The effects on clover population and seed production are likely to have been more severe in an adverse season.

SUMMARY

Morphological Effects.

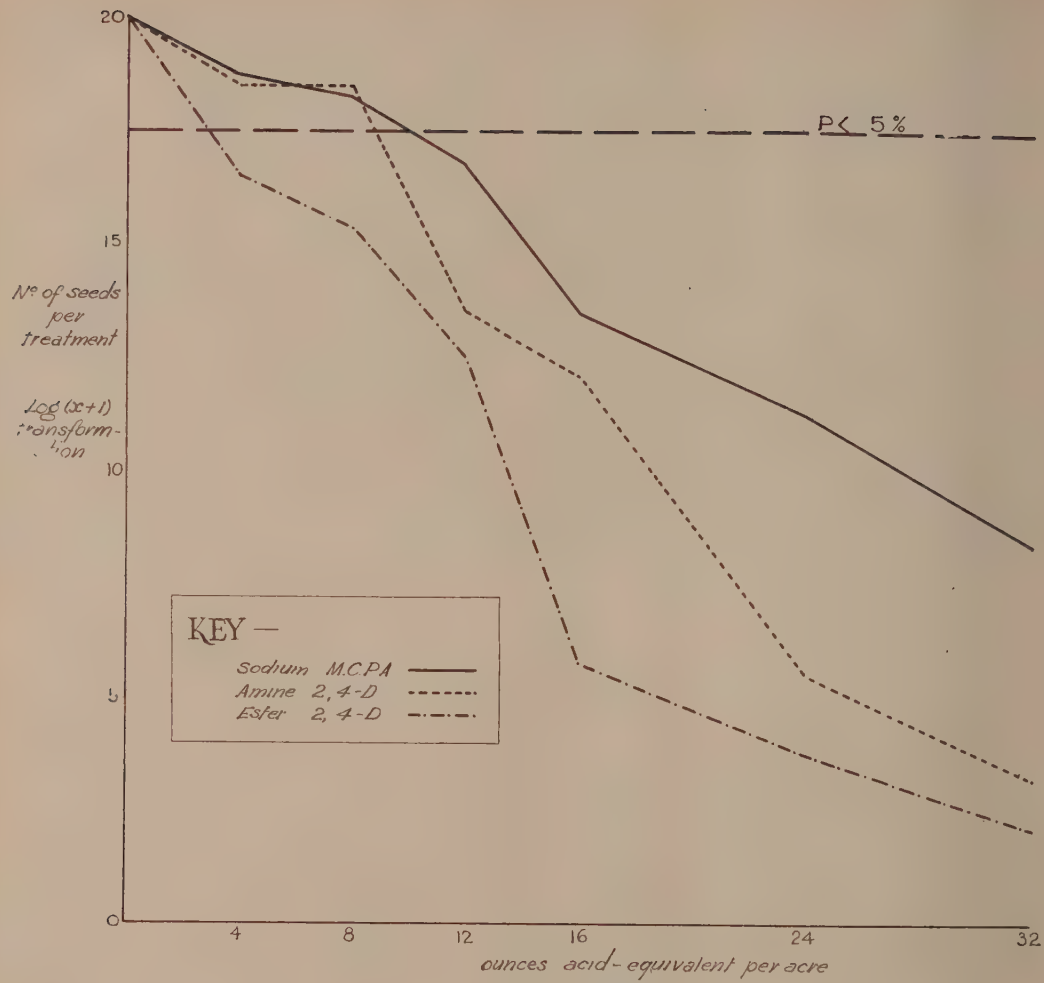
Morphological effects on the clover plants were related to both the formulation and the rate of application. Sodium M.C.P.A. caused the least effect, ester 2,4-D the greatest with amine 2,4-D intermediate. As was to be expected the degree of effect increased with the rate of application of each formulation but was not necessarily similar for the same treatment level at different centres. Obviously the effects are not independent of local variable factors.

The clover plants reacted in a number of different ways, the floral form including the stamens and carpel was not ob-



— GRAPH V —

Showing the effects of three formulations at different levels on the average number of flower-heads per plant (Geraldton)



— GRAPH VI —

Seed produced in relation to chemical applied (Geraldton)

viously altered by the growth regulators applied prior to flowering but the growth of flowers present at the time of spraying was generally arrested. With the higher rates, reduction in the length of runners caused a dwarfing which in extreme cases could be described as a rosetting. Besides being smaller, the leaves became narrow, wedge-shaped and a clearing of the veins was apparent. Severely affected plants were not unlike those showing a zinc deficiency.

Plant Population.

There was not a close correlation between clover plant survival at the three centres, indicating the effect of local conditions. Based on previous figures for pasture establishment the wastage on the control plots at Toodyay could be regarded as average and there was no greater reduction with any of the treatments. At Narrogin there was little or no difference between the initial and final counts with the controls and also a number of the

treatments. This is somewhat unusual and no doubt was due to very favourable conditions relative to moisture and freedom from weeds and insect pests.

The only appreciable reduction in plant numbers occurred with 32 oz. amine 2,4-D and 16, 24 and 32 oz. ester 2,4-D. Plant wastage during the season occurred on all plots at Geraldton, including the controls. It was most evident, however, in the case of the higher levels, particularly of amine and ester 2,4-D. The figures indicate that at Toodyay no reduction of plant numbers was caused by any treatment, at Narrogin 32 oz. amine 2,4-D and 16 oz. ester 2,4-D had effect, while at Geraldton the corresponding figures were 16 oz. sodium M.C.P.A., 12 oz. amine 2,4-D and 8 oz. ester 2,4-D. Although there was some difference in the size of the clover plants at the three centres, at the time of spraying all crops were at a favourable growth stage for treatment for weed control. It may be concluded that at the rates used in Western Australia for the control of cruciferous weeds there is little risk of causing a substantial reduction in the number of clover plants in a first year stand.

Flower Numbers and Periodicity.

The arbitrary method used in recording floral development has already been described. An accurate average figure for flowers produced per plant cannot be estimated because of the possibility of duplication with successive counts and direct comparisons cannot be made between the figures from the different centres because the number of counts made was not uniform. The procedure followed was considered to be the most practicable and supplied the information desired viz.: the effect of treatment on time of flowering and total flower production.

The reaction to treatment at Toodyay where the plants were flowering at the time of spraying was more marked than at the other sites where spraying preceded the initial flowering. All treatments caused a substantial reduction in the number of flowers formed. The higher rates caused the greater reduction but the formulations followed a similar pattern. The date of maximum flowering was delayed to varying extents and was influenced by both the formulation and rate of application. Four ounces acid equivalent M.C.P.A. per acre retarded the date by seven days; 8, 12, 16 and 24 oz. by 18 days and 32 oz. by 29 days. The effects of the amine and ester of 2,4-D were even more severe, the largest recorded delay in maximum rate of flowering being 42 days in the case of 32 oz. of ester.

At Narrogin there was a steep reduction in flower formation with all ester treatments. There was no decided decrease with 8 oz. of amine or 16 oz. M.C.P.A. but above these levels there was an obvious reduction. The flowering peak was not delayed by any of the M.C.P.A. treatments but was retarded 14 days by 24 and 32 oz. of amine and all ester rates with the exception of 4 oz. The restricted number of counts at Geraldton did not permit conclusions regarding effect of treatment on date of maximum flowering but the average number of flower heads per plant was reduced considerably by the higher rates, particularly of ester 2,4-D.

Seed Formation.

At Toodyay the number of seeds produced per plot was reduced at the higher levels of all treatments with a corresponding reduction in the average number of seeds per plant. At the $P < 5$ per cent. level, significant decreases occurred above 8 oz. acid equivalent ester, 16 oz. amine and 24 oz. M.C.P.A. An increase in seed production with 4 and 8 oz. M.C.P.A. could at first appear to be an anomaly. There was a similar trend at Narrogin, however, and the slight delay in flowering could have resulted in more favourable conditions for seed formation, temperature and light period being possible factors. Again the possibility of stimulation by small quantities of growth regulators cannot be excluded.

M.C.P.A. caused no significant reduction in seed setting at Narrogin which was also the case with amine 2,4-D except for the 32 oz. level. With the ester, however, all treatments above 12 oz. were significant and the 12 oz. level itself was marginal. The most marked reaction was recorded at Geraldton. All rates of 2,4-D, including 4 oz., caused a significant reduction in seed yield. M.C.P.A. and amine in excess

of 8 oz. also caused reductions with a tendency for M.C.P.A. to be less severe. Even below this level there was a trend with both formulations. With a number of the treatments the seeds produced were fewer than the plants on the plot at the time of the initial count.

The germination of seed from all plots at Toodyay and Narrogin was uniformly high. Figures for Geraldton were more variable but there was no big reduction in viability or relationship to treatment.

DISCUSSION AND CONCLUSIONS

Growth regulators applied to Dwalganup subterranean clover can cause several manifestations of agricultural significance without causing the death of the plants, in fact the lethal dosage is relatively high. The shape and size of the leaves, and length of the runners, may be affected, along with the floral development and subsequent seed setting. In the season of establishment the quantity of herbage for grazing is not an important consideration but the production of seed to ensure a satisfactory stand of clover the following year is vital. A reduction in the population of clover plants only occurred at rates in excess of those used for the control of such weeds as wild radish and wild turnip but the same could not be said regarding seed formation. With the three formulations used, the effects were related directly to the quantity applied, but ester 2,4-D was consistently more severe, with sodium M.C.P.A. least and amine 2,4-D intermediate.

When interpreting the results of the trials recorded, it is necessary to consider not only the tolerance of the clover but also the relative effectiveness of the treatments for the control of weeds. Most of the spraying of cereal crops in Western Australia is directed against wild turnip (*Brassica Tournefortii),* wild radish (*Raphanus raphanistrum*) and mustard (*Sisymbrium spp*). Wild turnip is highly susceptible and 4 oz. acid equivalent per acre of all formulations have given consistently good results. Wild radish and mustard, however, are more difficult to control chemically. Trials with wild radish by Meadly and Pearce (1954) showed that 4 oz. acid equivalent of ester 2,4-D per acre under favourable conditions gave a satisfactory degree of control. At the 6 oz. level the ester was completely effective. On the other hand 4 oz. of M.C.P.A. and amine 2,4-D affected a proportion of the wild radish plants but were not satisfactory. The 6 oz. rate of both gave reasonable control although some plants recovered and set seed and the treatments were less effective than 4 oz. of ester 2,4-D. For wild radish control, 4 oz. of ester approximates in effectiveness 8 oz. of M.C.P.A. or amine 2,4-D. With this evaluation the active isomer content of the M.C.P.A. was not taken into account, the rates being based on the active content as stated by the manufacterer.

Another important consideration when drawing conclusions and deciding practical recommendations is the influence of the very favourable 1955 growing season on the results. Virtually all treatments affect floral formation if applied after flowering commences but spraying is usually carried out before this growth stage has been reached. The main influence on seed setting and the capacity to produce a satisfactory stand of clover the following year, is the delay in flowering and consequently seed setting, due to treatment. As already outlined, the effective growth period was extended at all centres, the estimated increase being four weeks at Toodyay, three weeks at Geraldtion and nine days at Narrogin where a clay subsoil also assisted in retaining moisture. There is no doubt that in a less favourable season, the retarding of flower development would have a much greater influence on seed formation. The extended growing season at Geraldton was no doubt counterbalanced, in part at least, by the unthrifty condition of the young plants on a low fertility soil. The results at this centre probably gave the best guide to reactions that can be expected in an "average" season.

With due consideration to the variables already outlined the following recommendations are made:—

(1) Wild turnip in cereal crops can be controlled by 4 oz. acid equivalent per acre of amine 2,4-D and sodium M.C.P.A. When this is the only weed concerned and clover

plants are present one of these formulations should be used. It is scarcely necessary to add that 4 oz. ester 2,4-D is equally effective and would be quite appropriate to use for wild turnip control in the absence of clovers.

(2) With a first-year stand of clover grown with a cereal the use of ester, 2,4-D for the control of any weed is not favoured. Under such conditions 6-8 oz. acid equivalent per acre of amine 2,4-D or sodium M.C.P.A. should be used for wild radish and mustard. There is slightly less risk of affecting the clover with the M.C.P.A. but the amine gives somewhat better weed control at comparable rates. If the clover plants are unthrifty M.C.P.A. should be used. When the weeds are two to four inches across and growing actively, 6 oz. will give practical control but 8 oz. acid equivalent per acre is preferable, if conditions tend to make the weeds more resistant. Susceptibility decreases as the weeds become larger and also if growth is slow due to such factors as low temperatures or lack of moisture.

(3) In the case of a crop sown on old clover land, the procedure recommended for wild radish and turnip with a first year stand of clover would also be applicable. Where a substantial regeneration from dormant seeds can be expected, however, the stand is unlikely to be affected appreciably by 4 oz. acid equivalent ester 2,4-D per acre and this more active treatment could well be used when a crop is badly weed infested or conditions are not favourable for weed control with growth regulators.

(4) The above recommendations apply when spraying is undertaken at the optimum growth stage for weed control and during the period of minimum risk to the cereal. At this stage when the cereal is six to eight inches high and stooling, the clover plants are usually two to four inches across with four or more trifoliate leaves. Small clover seedlings may be killed by treatments that are quite safe at the later stage, while spraying some time after flowering has commenced can be very detrimental to seed setting.

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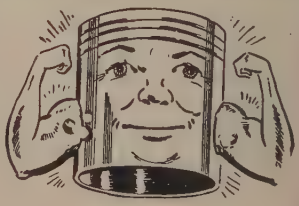

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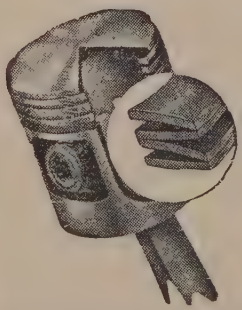

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Flowering Shrubs for all Seasons

By C. C. HILLARY

Fig. 1.—The sweetly-perfumed *Plumiera* or frangipanni.

NO garden is really complete without some shrubs and, where the area is large enough, a well-chosen collection can form an attractive feature throughout the year. Unfortunately, there are some who look upon shrubs merely as masses of evergreens suitable for filling odd corners or for providing screens. When planted with this unimaginative viewpoint in mind, they can hardly fail to be uninteresting and may, at times, be even unsightly.

Yet, so wide is the variety of plants from which a choice can be made that, instead of the monotony of evergreens such as privet, it is possible to secure subjects which combine attractive foliage with seasonal displays of delightful bloom. The wide range also makes it an easy matter to choose and plant shrubs which will provide a succession of flowers the whole year through.

In addition to their individual value as specimens for lawns and prominent positions, shrubs are also of the greatest use for providing backgrounds (and shade when required) for other flowers and for giving "height" to flat gardens.

The varying greens, greys and purples in a bank of foliage formed by a selection of shrubs planted in irregular formation around a drive, or a walk, can also form an attractive picture in any garden.

CHOOSE THE RIGHT POSITION

Most shrubs are easily cultivated, but that does not mean that they will prosper in any old soil or position. Some, like that beautiful foliage shrub, *Phyllanthus rosea,* are happy in full sunshine all day; others, such as most of the camellias, enjoy life better when they are shaded from the sun in the afternoon. Others again, like daphnes, gardenias, azaleas and fuchsias, do better in positions which are fully shaded for most of the day.

Once a shrub is planted, it should remain an honoured guest in the garden for many years. In view of this, it is only reasonable that it should be given a good start in life by being planted in a well-prepared site.

The soil should be enriched with old manure, blood and bone and compost, and, if the ground is heavy or low-lying, care

Fig. 2.—The Apple Blossom hibiscus—a deservedly popular summer-flowering shrub.

should be taken to see that it is efficiently drained. No shrub will thrive for long with its roots in stagnant water.

Another important point which should receive attention is the distance allowed between the shrubs. Far too often they are planted so closely together that within a few years they become overcrowded and some have to be removed—often when they are just coming to their best.

All shrubs should be given enough room to stretch their limbs in comfort. Let the height govern the distance apart. As a general rule, this is a fairly reliable guide. A shrub that grows 8ft. high should be allowed a circle of soil not less than 8ft. in diameter, a 6ft. shrub 6ft. and so on.

One more thing worth remembering when planting a group of shrubs is to place them so that they will all get a fair share of air and light. Do not surround a small shrub with three or four large ones. If you do, it will be hidden from view as soon as they grow up.

Life in a garden is said to commence in spring and, while that may be true in cold countries, it is hardly so here. However, to help those who wish to have shrubs in flower at all seasons of the years, I am commencing my recommendations with those that flower in spring.

SPRING FLOWERING

One of the earliest to flower is the lovely *Diervilla conquete,* which carries masses of dainty, pink bells down the full length of the stems. Of deciduous habit, it grows about 7ft. high and has very nice, light-green foliage.

A handsome native of South Africa, named *Psoralea pinnata,* produces its blue, pea-shaped flowers much about the same time. An evergreen, it will do better work in a cool district than a hot one but, wherever it grows, it will prove enjoyable. Height 6ft.

The salmon-pink *Rondeletia amoena,* with sprays of flowers after the style of a hydrangea usually commences flowering a little later—in October—and continues well into summer. The evergreen foliage is most attractive, but is easily damaged by frost. A really lovely shrub. Height 6ft.

Ceanothus Edwardsii is a handsome evergreen with small, shiny-green leaves, which spreads a mantle of blue in October and November. One of the finest of all blue-flowering shrubs and an easy one to grow, it also attains a height of about 6ft.

Choisya ternata is often known by the name of Mexican Orange Blossom owing to the delicious perfume of its flowers. It blooms for a number of weeks in spring and carries its closely-packed foliage all the year. Height about 4ft.

Then there is the Gardenia which commences flowering in late spring and continues into summer. Not satisfied with this, it blooms again in autumn. Most

attractive, glossy-green leaves make it worth growing for its foliage alone. Requires a shady position. Height 5ft.

The Chinese Lantern with the botanical name of *Abutilon* is yet another shrub I can recommend for its spring flowering. The orange-scarlet variety Eclipse is one of the best and it continues flowering over most of the summer. Of evergreen habit, it grows to about 6ft.

Although mentioned last, I consider *Brunfelsia latifolia* the most beautiful of all spring-flowering shrubs and that is saying quite a lot. An evergreen with bright-green foliage, which turns to bronzy-green in winter, it literally covers itself with blue and white flowers in October and November and then blooms intermittently until the end of autumn. Height 5ft.

SUMMER FLOWERING

In this section we have some very lovely shrubs indeed. Perhaps the finest is the *Lagerstroemia, w*hich commences flowering at the beginning of January and then continues to decorate every stem end with great bunches of dainty, crepe-like blossoms until the end of March. There are several varieties and they are all beautiful. A deciduous shrub, it requires really hard pruning each winter. Height 7ft.

The best of the summer-flowering evergreens is the Hibiscus. What pictures varieties like Agnes Galt (crimson) and Apple Blossom (pale pink) are capable of creating. They require warmth and water and do well near the seaside. Two other lovely varieties are Cameo Queen, a rich yellow with delightful pink stamens and Mrs. G. R. Davis, salmon flowers and most attractive bright green foliage. Height 5ft. to 10ft.

Clerodendron ugandense is a fine shrub for a warm situation, but it requires plenty of water. The blue flowers resemble butterflies and are very lovely. Evergreen. Height 5ft.

The *Plumiera* which is better known as Frangipanni is already a popular shrub. A native of the tropics, it is suitable for planting only in frost free areas and requires plenty of water in summer. While there is a certain stiffness about the foliage, the flowers are freely produced over most of the summer and are sweetly perfumed. It is deciduous and grows to a height of 8ft.

The *Lasiandra* is a beautiful shrub which carries its rich purply-blue flowers through summer and autumn. It requires a warm position and objects to frost. To keep it shapely, it should be pruned at the end of winter. Sometimes the family name of *Tibouchina* is used instead of *Lasiandra.* Evergreen. Height 7ft.

Fig. 3.—Hydrangeas make an attractive showing in a shady situation.

Varieties of hydrangea are worth cultivating in every garden. They make a magnificent show in December and January when grown in banks of six or a dozen plants and generally do best in positions which provide shade from the afternoon sun. Deciduous. Height 3ft. to 6ft.

Iochroma tubulosa is another fine summer shrub which carries plenty of attractive violet-blue flowers. A sunny position suits it best and it needs pruning after flowering to encourage young growth. Evergreen. Height 6ft.

Fig. 4.—The brightly-hued berries of the *Cotoneasters* are always popular as indoor decorations.

AUTUMN FLOWERING

Some of the shrubs mentioned in the summer list continue flowering well into autumn. The gardenia, *Abutilon* and *Brunfelsia,* which are included in the spring list, also flower in autumn.

One of the loveliest of the real autumn flowering shrubs is *Cassia candolleana.* With its very rich, pea-shaped, yellow flowers it reminds me very much of the laburnums which thrive so well in colder countries. *Cassia candolleana* carries its flowers in great clusters for six or eight weeks and the bright green foliage is attractive all the year. Height 6ft.

Other beautiful autumn shrubs are the *Cotoneasters* and *Pyracanthas* which adorn themselves with red or orange berries and carry them through the autumn and winter almost into spring.

One of the finest *Cotoneasters* is *Pannosa,* which has silver-green foliage and scarlet berries clustered in thick masses down every stem and limb. Another is *Serotina* which has large foliage and large scarlet berries, carried in bunches. Many of the leaves assume crimson tints in autumn. Both are evergreen and grow to 8ft.

The two finest *Pyracanthas* are *Yunnanensis* and *Lalandei.* The former has scarlet berries and the latter deep orange. Both are easily grown in almost any soil. *Yunnanensis* is of spreading growth; about

5ft. high and 8ft. across. *Lalandei* grows in normal fashion to 6ft. The only obectionable feature about these shrubs is the prickles.

Holmskoilda is another attractive autumn shrub with blood-red flowers. It does not grow much above 3ft. high in this climate and is evergreen. It does best in a warm, sheltered position and requires liberal watering in summer.

WINTER FLOWERING

In this section we have the finest of all evergreen shrubs, the very lovely Camellia. There are numerous varieties and they flower all winter. Even when the blooms are absent, their highly polished foliage makes them exceedingly ornamental. One of the loveliest scarlet varieties is the Czar with large, almost single flowers with charming golden stamens.

Another is the salmon-coloured Edward Billing with flowers that resemble huge paeonies. No one will ever regret planting this glorious camellia. Then there is Purity, a formal white with flowers so chaste that one can sit and admire them for hours.

Emperor Variegata, a rich crimson with white blotches, is another charming sort, and so is Odoratissima, a lovely bright scarlet and one of the few camellias that have perfumed flowers. All are evergreen. Height from 4ft. to 10ft.

The sweetly perfumed Daphne which grows 4ft. high and up to 5ft. across also flowers all winter. It requires full shade or nearly so and, like the camellia, it does best in an acid soil.

The pink and red-flowered *Leptospermums* should be much more popular than they are. They carry masses of flowers in winter and early spring and grow readily in most loamy soils that are kept reasonably moist in summer. All are evergreen and they range from 3ft. to 5ft. in height.

The blue-flowered *Veronica Andersonii* is also well worth growing for its winter flowers. It has attractive, small green foliage and forms a very neat bush with the assistance of an occasional trimming. Evergreen. Height 5ft to 6ft.

It is during their first year in the garden that the shrubs you plant will need your assistance most. It is then that they dig their toes in an endeavour to make themselves comfortable.

Make sure that they do not want for water, keep them well secured to stakes so that they will not be blown over by wind, and place a good mulch of old manure, straw, or compost around them at the end of spring.

In the second year they will be fairly well established and better able to stand on their own feet. A helping hand, however, will always be appreciated and rewarded with additional flowers and better foliage.

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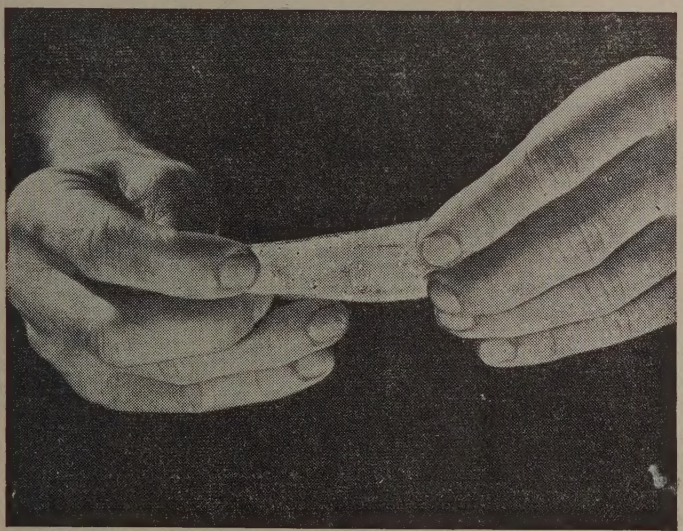

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Book Review

A TRACTOR HANDBOOK

Written for farmers, farm workers and agricultural students who want to know not only how a tractor should be used but also how it works, this fifth edition of "TRACTORS ON THE FARM" has been enlarged and drastically revised.

Using a clear and simple style throughout, and with the help of many drawings and photographs, the author describes the mechanical principles of all classes of tractor in greater detail than before, paying special attention to the increasingly popular diesel engine. The merits of different tractor fuels and the factors to consider in choosing a tractor, including the British Standard and National Institute of Agricultural Engineering tests, are discussed. Several chapters are devoted to the important topics of servicing and maintaining a tractor. Other points covered include using accessories, carrying out conversions, the requirements of comfort and safety, and the buildings and installations ancillary to tractor operation. To conclude, the author gives tips on how to get the best out of a tractor.

Previous editions of this book have been recommended text books for the syllabus for the Bachelor of Arts degree in Agriculture of Cambridge University, and were also on the lists for the National Diploma in Agricultural Engineering and the City and Guilds Farm Operator's Certificate. In framing the present edition, therefore, care has been taken to ensure that the current requirements of these examinations are met as far as the subject of tractors is concerned. Moreover it remains the best practical guide to the man who wants to get the utmost service out of his tractor in the field.

"Tractors on the Farm: Their Choice, Use and Maintenance" by H. J. Hine, B.Sc. (Oxon.), Dip. Rur. Econ., M.I.B.A.E., Fifth Edition. Published by Farmer & Stock-Breeder Publications Ltd., Dorset House, Stamford Street, London, S.E.1. Size 8¾in. x 5½in., 247 pages. 73 photographs (art plates) and 79 diagrams in the text.

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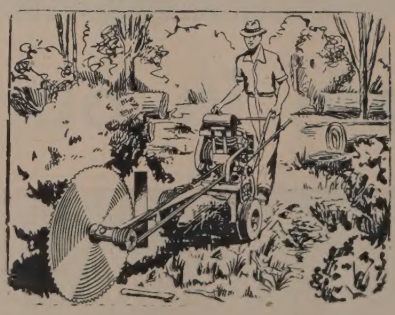

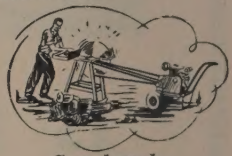

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